COLEBROOK RIVER LAKE
COLEBROOK, CONNECTICUT

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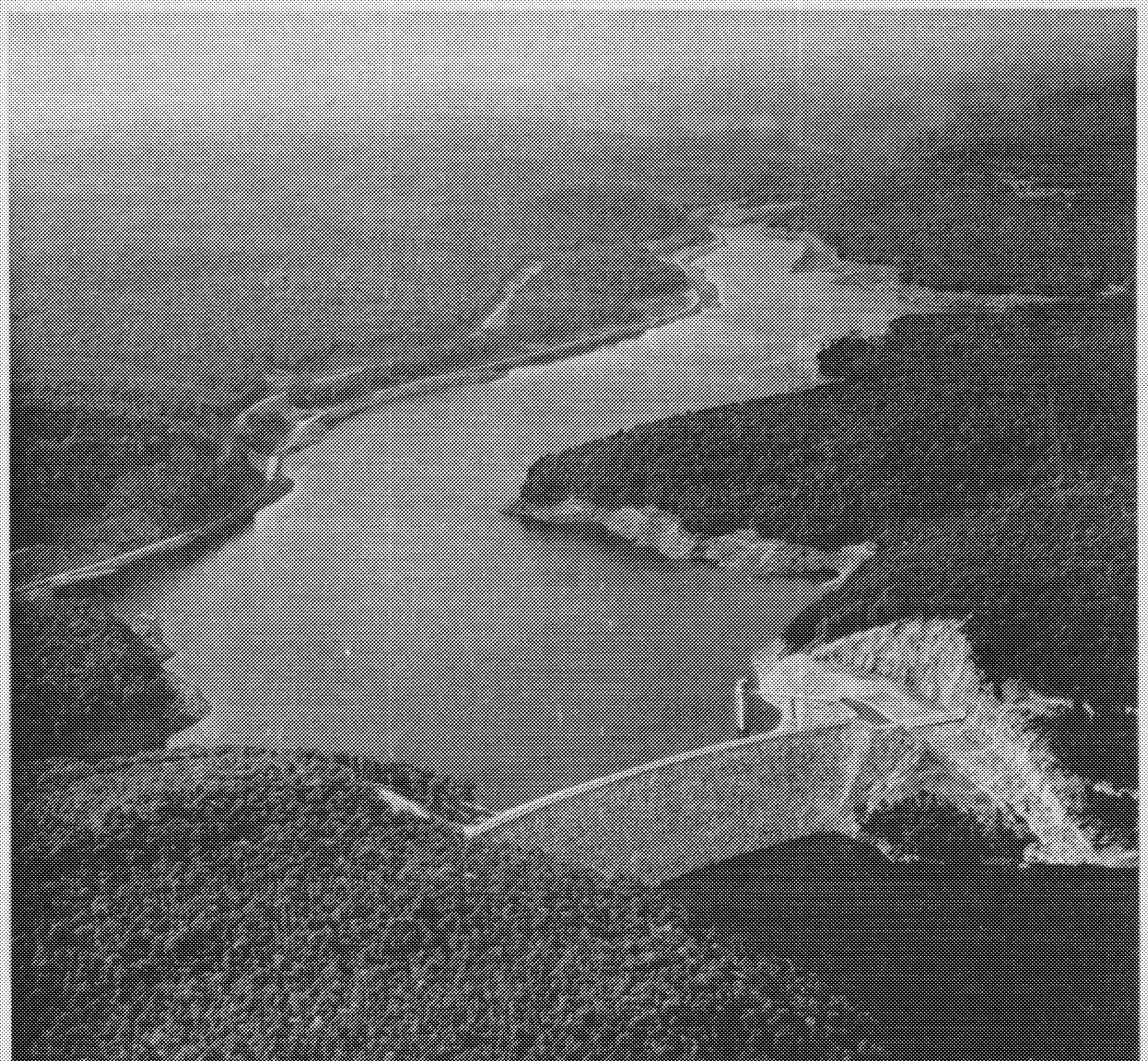
HYDROPOWER DEVELOPMENT

Preliminary Feasibility Study



United States Army
Corps of Engineers
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New England Division

FEBRUARY 1981

Executive Summary

This preliminary feasibility report on the inclusion of hydroelectric power as an added project purpose at the existing Colebrook River Lake in Colebrook, Connecticut was conducted to determine the need for detailed study. Further or additional reports recommended as the result of this preliminary study would be prepared using the specific authority contained in the resolution of the Committee on Public Works of the Unites States Senate adopted 11 May 1962, relating to development of a comprehensive plan for the Connecticut River Basin.

Colebrook River Lake, which has been operational since 1970, is a multipurpose project for water supply, flood control and fishery resources. It is located on the West Branch Farmington River just upstream of the Goodwin Dam and West Branch Reservoir. The latter, with its upper reservoir extremities lying within the Colebrook River Lake impoundment is owned and operated by the Hartford Metropolitan District Commission (HMDC) and is also drafted for water supply.

Results of these studies indicate that the project site is a viable candidate for developing hydropower as a nonfossil and renewable energy resources. It is located in a watershed where the management of water resources is of general interest, and a climate of acceptability exists for such an endeavor.

New England's current dependence on expensive imported oil has aroused new interest in using the region's numerous rivers for hydroelectric power. The proposed hydroelectric power development at an existing Corps of Engineers dam would help to reduce national and regional dependence on oil for electric energy production, and improve New England's energy independence by encouraging development of renewable energy resources.

Five alternative plans were evaluated for harnessing the hydropower potential of the project site. All alternatives were analyzed assuming a single hydropower unit to be sited at the downstream end of the existing Colebrook River Lake outlet, with a steel liner installed for use as a penstock. This would limit the installed hydraulic capacity of the hydropower facility to approximately 600 cubic feet per second (cfs).

The plan of development for Alternative 1 is based on the outflows and heads as experienced over the 9-year historical operating period. Alternative 2 would harness the same outflows except there would be a reallocation of storage between Colebrook River Lake and the downstream West Branch Reservoir, thereby increasing the hydraulic head between the two reservoirs while still meeting the same project purposes. Alternative 3 would be identical to Alternative 2, but as the project is well suited for pumped storage, chiefly because the required headwater and tailwater pools are already in existence, the hydropower facilities of Alternative 2 would be made reversible. Alternative 4 would involve Alternative 2 storage reallocation plus the addition of bascule gates on the Colebrook River Lake spillway, thereby increasing the regulated storage capacity at Colebrook River Lake for added hydropower head. Alternative 5 would be identical to Alternative 4 except that the hydropower installation would be made reversible for the same purpose as advanced for Alternative 3. The basic differences between Alternatives 1, 2 and 4 are graphically illustrated on Plate 11, Section III of the text.

A cursory look at another plan was conducted, and the plan was determined to be outside the realm of this study. The plan involved a high head pumped storage project, referred to as "The Tolland Center Pumped Storage," as documented in the New England River Basins Commission report, dated July 1973. This proposal would have its lower pool located within the confines of the Colebrook River Lake Reservoir, and as such is still considered a viable project. However, when and if ever implemented, it should have no economic impact whatsoever on the Colebrook River Lake hydropower potential. However, the social and environmental impacts of the pumped storage concept would need to be addressed.

Alternative 1 was analyzed assuming a 2.5 megawatt (Mw) unit with a 60-foot design head and a resulting design hydraulic capacity of 614 cfs. The installation would be capable of harnessing nearly the full hydropower potential of the outflows from Colebrook River Lake and result in an average annual generation of 8,100 megawatt hours (Mwh). The average annual generation for Alternatives 2 and 3 would be 13,600 Mwh, based on a 3.5 Mw unit, a 90-foot design head and a resulting design hydraulic capacity of 570 cfs. The economic benefit to be derived from the reversible unit of Alternative 3 would be to provide dependable capacity and would be evaluated at 2.0 Mw with an assumed maximum head of 50 feet. The total potential energy output for Alternatives 4 and 5 would be 18,900 Mwh, produced from an installation of 4.0 Mw, and based on a design head of 100 feet and a hydraulic capacity of 590 cfs. Alternative 5 dependable capacity concept, evaluated at 2.5 Mw with an assumed minimum head of 65 feet, would be identical to Alternative 3 for deriving economic benefits from its reversible unit.

The reversible unit concept would add to the operating flexibility, dependability and marketability of either Alternatives 3 or 5, however, as previously stated, justification would be based on the economic benefit to be derived from the dependable capacity. The associated pumping cost would be assumed such that the net annual energy production would be equal to that of either Alternative 2 or 4, as applicable, and that there would be no net gain or loss due to pumping. That is, the difference in cost of energy for pumping and the value of added generated energy would be sufficient to offset the energy loss in the operation of either Alternative 3 or 5.

As this feasibility report is preliminary in scope and the installed capacity of each alternative is relatively small, Alternatives 1, 2 and 4 would be considered principally as energy producing "fuel saving" type projects. Therefore, benefits derived for project justification would be determined by the price for which power could be sold. Subsequent studies would determine if credit for dependable capacity would be allowed, either as a benefit or credit reduction in project costs. It is for that reason that retention of Alternatives 3 and 5 to supersede Alternatives 2 and 4, respectively, would be held in abeyance at this time.

The values at which Alternatives 1, 2 and 4 would be economically justified were respectively estimated to be 53.8, 34.5 and 39.3 mills per Kwh, or simply 5.4, 3.5 and 3.9 cents per kilowatt hour. Since benefits for Alternatives 3 and 5 would be for dependable capacity and are currently nonquantifiable, values at which those alternatives could achieve project justification are estimated to be $34.15 and $26.76 per Kw of dependable capacity for Alternatives 3 and 5, respectively. All of the stated values are exclusive of the relative price shift analysis. However, relative price shift analysis, to reflect real escallation in fuel costs, has been addressed and is documented in Section VII of the text.

With the addition of hydropower as an added project purpose to Colebrook River Lake, this study recognized that a new cost sharing arrangement would have to be developed between the Federal Government and the Hartford MDC for joint use of the Corps facilities. Therefore, appropriate cost allocation studies and modification to the existing contract are envisioned and would be pursued as the study progresses.

The proposed project complex (Colebrook River Lake and West Branch Reservoirs) would have no measurable impact on the topography, geotechnical features or climatology of the area. Impacts to the aquatic and terrestrial ecosystems, the recreation and natural resources, the historic and archaeological resources, and the socioeconomic resources would vary accordingly with each alternative.

Alternative 1 would produce little or no adverse impacts as operation of the project would be essentially the same as at present; and, exclusive of the power facilities, no modification to project features is envisioned. For Alternatives 2 and 3 adverse impacts would be present but are considered relatively insignificant with some exceptions. Impacts of significance would include an additional 40 acres of reservoir clearing along the periphery of the reservoir; and the lowering of the West Branch Reservoir by 31 feet and subsequent raising of Colebrook River Lake Reservoir, thereby requiring the boat launching parking area and ramp to be raised by 4 feet. Alternative 3 with its pumpback operation could produce additional impacts, such as increased mixing resulting in modified stratification and a change in overall water quality conditions in Colebrook River Lake Reservoir. Shoreline erosion and related impacts in both reservoirs would also be more prevalent than anticipated in Alternative 2, in that they would be exacerbated by the more frequent pool level changes, and the characteristic pumpback mode of several consecutive changes occurring through a single series of pool elevations.

Alternatives 4 and 5 would produce significantly higher normal pool levels in Colebrook River Lake Reservoir and thereby increase the magnitude of all of the effects indicated for Alternatives 2 and 3. Additional requirements for Alternatives 4 and 5 would include clearing of 110 acres of reservoir along the periphery of the reservoir; total relocation of existing and future recreation resources; and acquisition of 160 acres of land including one commercial and nine residential properties in Sandisfield, Massachusetts, together with another 190 acres of flowage easements, of which 60 acres would be in Connecticut. Alternatives 4 and 5 could also have effects upon historic period cultural resources.

Based on project justification and impacts of each alternative the most likely candidate for the selected plan at this time would be Alternative 2. It would be considered principally an energy producing "fuel saving" type project with no benefits claimed for any dependable capacity. It is noted, however, that available generation could be generally forecasted on a week-to-week basis. Except during flood regulation, releases are made from Colebrook River Lake weekly at the request of the Hartford MDC and/or the Connecticut Department of Environmental Protection. The Hartford MDC is required to discharge 66,600 acre-feet annually from its system of reservoirs in the basin for use by downstream riparian owners, and 53,400 acre-feet must be discharged between 15 May and 31 October. Secondly, no less than 50 cfs outflow must be maintained at all times at the downstream Goodwin Dam and only inflows in excess of 150 cfs can be stored. During the summer months, June through October, releases from Colebrook River Lake are generally scheduled weekly and are equal to inflow plus planned releases from storage resulting in an augmented outflow and falling reservoir level. During the winter months, November through February, only inflows in excess of 150 cfs are stored, usually resulting in a gradual filling of storage. Once the water supply storage is filled, either during the winter or spring runoff period, outflow is generally maintained equal to inflow until the following summer season, except for short duration flood regulation.

With the plan of operation for Alternative 2, it is expected that the downstream West Branch Reservoir would be used as a reregulating reservoir, permitting the Colebrook River Lake project to operate in an "on-off" mode, fitting generation to power demand, within the limits of the average weekly flow requirements and resulting available head. The hydraulic capacity of the project would be in the order of 600 cfs; therefore, average daily hours of generation might vary from 7 hours per day in October and November when average flow is about 175 cfs to about 20 hours per day in April when average flow would be nearly 500 cfs. The all season average annual plant factor would be about 44 percent or about 11 hours generation per day. Maximum rates of pool level change due to the proposed hydropower operation would be about 0.3-0.5 ft/hr in the downstream West Branch Reservoir and 0.1 ft/hr in the Colebrook River Lake. Maximum daily fluctuations as a result of hydropower operations should not exceed 6 feet in the West Branch Reservoir and 2 feet in Colebrook River Lake. Rates and magnitudes of fluctuations are considerably greater during periodic flood regulations. The existing outlet capacity at Goodwin Dam is limited to about 1,000 cfs. Therefore, during floods and high flow periods, the West Branch Reservoir would fill to elevation 641 feet NGVD to permit utilizing the spillway for the passage of high flows and the emptying of floodwaters from storage, first from Colebrook River Lake and then from the West Branch Reservoir.

No effort was made in this study to develop an optimum plan of operation with hydropower as an added purpose for Alternative 2. Hydropower was assumed an incidental purpose, and it was assumed that the project would be operated as in the past to meet the same downstream flows. Only the change in storage allocation between Colebrook River Lake and West Branch Reservoir was considered in the interest of increased hydropower generation. Further optimization studies would be a part of any more detailed design and would likely be periodically reviewed after project completion.

The hydropower installation would have a synchronous generator rated 4375 kilovolt amperes (Kva), 0.8 power factor (PF), 3-phase, 60 hertz (Hz), 5.0 kilovolts (Kv), 900 revolutions per minute (rpm). The turbine would be a single, vertical propeller Kaplan runner with adjustable blade unit and equipped with wicket gates. The Kaplan unit would have a high operating efficiency under varying range, 60 to 140 percent, of design head; and would also operate quite efficiently under varying discharges, 40 to 105 percent, of design capacity. The throat diameter would be 4.6 feet. Assuming a combined turbine and generator efficiency of 80 percent, the output of the generator, based on a 90-foot design head and a design hydraulic capacity of 570 cfs, would be approximately 3.5 Mw. The average annual generation would be 13,600 Mwh at an average annual plant factor of 44 percent. Total project cost for Alternative 2 is estimated to be $5,720,000 with annual charges of $469,200 and an energy cost approximating 34.5 mills/Kwh.

A tabular summary of the hydrological and cost/benefit data for Alternative 2 appears in Table 1. Similar and comparative data for all five alternatives are further displayed in Table 21 of Section IX of the text.

TABLE 1

ALTERNATIVE 2 - PERTINENT DATA

Number of Units	1
Throat Diameter (ft)	4.6
Design Hydraulic Head (ft)	90
Generator Capacity (Kw)	3500
Generator Type	Synchronous
Hydraulic Capacity (cfs)	570
Potential Annual Generation (Kwh)	13,600,000
Annual Plant Factor	0.44
Average Turbine/Generator Efficiency	80%
Type of Turbine	Vertical Propeller with Kaplan Runner
Annual Oil Savings (barrels)	19,200
Total Investment Cost	$5,720,000
Annual Charges	$469,200
Energy Cost (Mills/Kwh)	34.5

The current acceptance of Alternative 2 as the selected plan would in no way preclude the retention of the other four alternatives or any others that may surface as the planning process continues. The final determination and recommendation of the most economically viable and acceptable alternative would be held in abeyance, pending more detailed studies and public involvement. Subsequent studies would develop within the framework of the Principles and Standards (P&S) both a National Economic Development (NED) Plan and an Environmental Quality (EQ) plan that would sustain the hydroelectric power potential as an integral part of the project purpose while enhancing, preserving and maintaining the water and related land resources of the project area.

COLEBROOK RIVER LAKE
HYDROPOWER DEVELOPMENT

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Introduction

SCOPE OF WORK

Preparation of this report comprises Stages 1 and 2 for the study activities of a Feasibility Report in the evaluation of hydroelectric potential at Colebrook River Lake, an existing dam site owned and operated by the Corps as a multi-purpose project for water supply, fish conservation and flood control.

Plans assessing the hydropower potential at that Federal project were developed to be compatible with the authorized purposes.

AUTHORIZATION

Authority for preparation of this report is contained under Section 216 of Public Law 91-611 which states:

> "The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found advisable due the significantly changed physical or economic conditions, and to report thereon to Congress with recommendations on the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest."

Further or additional reports recommended as the result of this preliminary feasibility report on the inclusion of hydroelectric power as an added project purpose at the Colebrook River Lake in Colebrook, Connecticut would be prepared using the specific authority contained in the resolution of the Committee on Public Works of the United States Senate adopted 11 May 1962:

> "RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE that the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved 12 June 1902, be, and is hereby, requested to review the reports of the Connecticut River, Massachusetts, New Hampshire, Vermont, and Connecticut published as House Document Numbered 455, Seventy-fifth Congress, second session, and other reports, with a view to determining the advisability of modifying the existing project at the present time, with particular reference to developing a comprehensive plan of improvement for the basin in the interest of flood control, navigation, hydroelectric power development, water supply and other purposes, coordinated with related land resources."

PROJECT HISTORY

Since the early 1900's the Farmington River watershed has experienced seven major floods. The record flood of August 1955 caused 31 deaths within the basin and at today's price level the estimated property damage would be in excess of $150,000,000.

Prior to that time, there existed only one Federal flood control project in the basin, namely, a channel improvement project on the Mad River in the city of Winsted, Connecticut, which was authorized by Public Law 72-228 and completed in 1951. As a result of the 1955 catastrophic event, the Corps of Engineers under Congressional mandate developed a water resource plan for the Farmington River watershed which led to the construction of three reservoirs, one channel improvement and several flood plain information studies. These reservoirs are Colebrook River Lake, a multipurpose project which helps to desynchronize downstream floodflows particularly along the Connecticut River; and Mad River and Sucker Brook prjoects, both functioning primarily to reduce flooding along the Farmington River as well as the West Branch, Mad and Still Rivers. Locations of these reservoir projects are shown on Plate 1.

The Colebrook River Lake project was authorized by the Flood Control Act of 14 July 1960, Public Law No. 86-645, in accordance with the recommendations of the Chief of Engineers set forth in House Document No. 443, 86th Congress, 2nd Session. This authorization provided for both flood control and water supply as project purposes. Fish and wildlife conservation was subsequently added as a project purpose, and the provision of storage for this purpose received its authorization from the Fish and Wildlife Coordination Act of 12 August 1958, Public Law No. 85-624. Project construction was initiated in April 1965 and became operational in 1970.

SOURCE OF INFORMATION

Data utilized in preparing this study were obtained by personnel from the New England Division, Corps of Engineers (NED) from site inspection of Colebrook River Lake, "as-built" drawings and reports including other technical information available at NED. Contacts with concerned agencies of the Commonwealth of Massachusetts and the State of Connecticut were initiated and their responses have been appropriately incorporated in the report. Their letter replies are included as Appendix A and B, respectively. In addition, information relative to mechanical and electrical features was either obtained from manufacturer literature or verified by representatives of appropriate manufacturers.

Under the authority of Section 5 of the 1944 Flood Control Act, the U.S. Department of Energy (DOE) would be responsible for marketing all electric power developed from the Colebrook River Lake project. That statute requires that power be sold in such a manner as to encourage the most widespread use thereof at the lowest possible rates consistent with sound business practices. Section 5 further directs that preference in the sale of power and energy is to be given to public and cooperative power interests.

In view of that mandate, inquiries relating to distribution and marketability of the potential hydroelectric generation were tentatively discussed with the Massachusetts Municipal Wholesale Electric Corporation (MMWEC) letter attached as Appendix C who acted as liaison with their counterpart, the Connecticut Municipal Energy Cooperative (CMEEC) of Groton, Connecticut, both of whom are public utilities. The Hartford Metropolitan District Commission (HMDC), a public agency with water supply investure in the proposed project, and the Northeast Public Utilities were also consulted and informed of the applicable authority.

Discussion with an appropriate Federal marketing agency to be established for the area at some future time; the Federal Energy Regulatory Commission (FERC); as well as other concerned Federal and non-Federal interests will be pursued in conformance with Section 5 of the 1944 Flood Control Act in subsequent stages of the planning process.

GOALS

This report will demonstrate the ability to develop a nonfossil, renewable energy resource from an existing Corps project currently void of hydroelectric generation which will:

Result in a maximized contribution to the national economy;

Promote the economic development of the region;

Operate to preserve the valuable features of the natural environment;

Provide a reduction of national and regional dependence on oil for electric energy production; and

Improve New England's energy independence by encouraging development of natural renewable energy resources.

PROBLEMS, NEEDS AND OPPORTUNITIES

The New England region must reduce its dependency on imported foreign oil, and other nonrenewable fossil fuels for the production of energy generation. In achieving that objective, it must develop and improve any of its native renewable energy resources that will provide a dependable and economical supply of electricity. As that mission is of paramount importance to the people of New England and to the economy of the region, any conceivable measures or methods that could improve the current and projected energy generation needs should be explored.

From statistical data published by the Electric Council of New England, the composition or types of fuels utilized by the electric utility industry for New England's electrical generation mix in 1979 is as follows:

NET ENERGY GENERATED
(1979)

Types	Million Kilowatt Hours	Percent of Total
Gas	197	0.3
Hydro	4,518	5.8
Fossil	46,648	59.6
Nuclear	26,729	34.1
Internal Combustion	161	0.2
Total	78,253	100.0

In 1979 fossil fuel consumed amounted to approximately 1,150,442 tons of coal; 9,201,969 million cubic feet of gas; and 71,779,082 barrels of oil. Oil is the primary fuel used in New England, followed closely by nuclear. This unusual fuel mix results primarily from the fact that New England has to date discovered no significant conventional energy resources of its own (other than water) that can be used in central generating stations. It must rely on other regions and principally on other countries for its coal, oil, gas and uranium.

Nuclear plants currently provide about 34 percent of New England's generation, and despite increasing reliance on nuclear generation, fossil-fueled steam plants continue to supply the largest part of New England's energy requirements. Hydroelectric provides only 6 percent of the power generation produced from a total hydroelectric system capability of 2,696 Mw (4,518 million kilowatt hours) of which 1,477 Mw is principally generated from pump storage.

Projected forecasts indicate that energy demand will continue to increase at a rate of 2.6 percent per year. The fuel mix prevailing in 1995, based on New England Power Pool's planned purchases, retirements and year growth, will be approximately the following:

PROJECTED 1995 GENERATION MIX

Types	Percent of Total Generated	Percent Change From 1976
Gas	0	- 0.4
Hydro	11.7	+ 4.8
Coal	17.3	+ 14.7
Oil	37.8	- 19.1
Nuclear	33.2	0

For all practical purposes, electric generation by gas would be nearly phased out over time with no change occurring in nuclear generation. Major changes would be a decrease in fuel oil to be displaced by an increase in coal generation.

To reduce New England's dependence on oil for the production of electrical energy, a number of management measures could be employed. Structural measures could include: converting more oil-fired facilities to coal; building additional coal and nuclear facilities; constructing hydroelectric and tidal power projects; and developing alternative energy sources including, but not limited to, wind, passive solar, coal liquidification, photovoltaics, wave action, geothermal, wood, and other biomass and purchases of imported power. Nonstructural measures would consist manly of conservation and load management. A brief discussion of some of those measures, including inherent advantages and disadvantages, is presented below.

Conversion of more oil facilities in New England to use coal as a fuel has directly reduced the amount of oil needed for electric energy production. Though the concept is technically sound and economically implementable at many facilities, the conversion, is not without problems. Key factors that must be considered are the availability of water or rail transportation facilities and protection of ambient environmental quality.

The construction of new coal and nuclear facilities could also directly reduce oil use. However, new coal facilities have problems similar to converted facilities and the current social-political climate in New England makes development of nuclear projects difficult, if not impossible. It is known that nuclear power, in short term, is a viable method of displacing large amounts of oil generation. However, nuclear power expansion has essentially stopped during the last few years, and it is not known what its future will be in New England.

Hydroelectric facilities including run-of-river, pumped storage, conventional and tidal power could also directly reduce the amount of oil used for generation. While these projects do not degrade air quality, or create dangerous waste materials, they tend to permanently alter existing physical conditions at the project site, sometime displacing inhabitants and adversely affecting resident wildlife. The fuel, water, is a renewable resource.

Windpower, one of the oldest forms of energy, is clean and many sites are available in New England. Windpower energy is intermittent, as is energy from either tidal power or run-of-river hydropower projects. Energy from such projects is dependent on natural phenomena, wind, tides and runoff. Man cannot control the availability of fuel, but in the case of tidal power or run-of-river power energy, he can predict availability with reasonable accuracy. Passive solar is basically an at-site technology. It is useful for space and hot water heating but unadaptable to large centralized facilities. Liquified coal, photovoltiacs, nuclear fusion and biomass will, perhaps, be the predominant energy sources of the 2000's. Once fully developed, these technologies could lead to energy independence for the region and the nation. New England is fortunate with respect to energy sources, in that it has wood and water in abundance. Wood, though renewable, is not nearly as attractive as hydropower or any of the other solar technologies (direct, wind, passive). It takes several years to renew the wood resources, whereas solar resources, tides, runoff, wind and sunlight are continuously renewed. Even though purchase of imported power from Canada could reduce our direct dependence on oil, it would do little to enhance our energy independence.

Conservation would be one of the best short term answers to oil use reduction. Smaller, more efficient automobiles, lowered thermostat settings, insulation and other conservation methods could directly reduce oil use but with resultant impacts on lifestyle.

Load management is primarily aimed at rearranging the timing of electric demand which involves changing people's habits. Once established, load management would allow more use of base load and intermediate power sources (lower cost, less oil-dependent coal, nuclear and hydroelectric) and require less peaking power (expensive pumped storage and oil dependent combustion turbines). Of course, load management assumes that the use of nuclear and coal energy will continue to increase.

Inasmuch as any of these management measures would help to alleviate, to some degree, the energy problems within the region, they are not a panacea to the energy crisis. It would also be reasonable to postulate that major technological breakthroughs regarding renewable energy resources are unpredictable, and would not be developed to the extent that they could be integrated on a large enough scale for satisfying New England's energy requirements as well as displacing its oil generation for several decades.

If the region is to achieve self-sufficiency in energy, thereby totally divorcing itself from its dependency on foreign oil for electric generation, it is imperative that the availability of any dependable and economical supply of electricity from any regional natural resources be fully explored.

One of the many ways to achieve that goal would be to place more emphasis, if possible, on hydroelectric power which is an abundant, pollution free, renewable natural resource, and an economical and safe source of energy. In the past, hydroelectric energy has had to complete with oil burning steam plants when crude oil could be purchased for a nominal price of $1.70 per barrel, as in 1971. With our present dependency upon imported foreign oil and subsequent skyrocketing price of fuel, the electric rates in New England have become alarmingly high, in fact, among the highest in the nation. In the meanwhile, the ultimate costs of nuclear plants and the existing social-political climate has led to the curtailment of new proposed nuclear plants as potential substitutes to oil generation. Hydroelectric energy therefore becomes an attractive alternative. The installation of hydropower at Colebrook River Lake could add an important power source for the region as long as it can be viably provided at a reasonable cost.

The amount of hydroelectric power derived from this project would be relatively small when compared to the total regional system load. Variations in the mode of operation would also have little or no impact on the operation of the total existing power system. Its capability would be equivalent to about 0.02 percent of current regional energy generation needs. The hydroelectric output of Colebrook River Lake proposal would be considered principally an energy producing, "fuel saving" type project which could be classified as secondary energy, usuable for thermal energy displacement. However, use of the project's hydropower potential could be a step toward the region's achievement of energy self-sufficiency.

Profile of Existing Facilities

PHYSICAL AND INSTITUTIONAL SETTING

General

The Colebrook River Lake Dam is located in northwestern Connecticut in the town of Colebrook and situated on the West Branch of the Farmington River as shown on Plate 1. The reservoir area, formed by the project dam, covers a surface area of 1,185 acres at spillway crest and encompasses portions of the counties of Berkshire and Hampden, Massachusetts and Litchfield, Connecticut. The dam lies about halfway between the community of Riverton and the abandoned village of Colebrook River, from which the project derives its name. The dam embankment is also situated within the pool of West Branch Reservoir, which is formed by the James Goodwin Dam, owned by the Hartford MDC. The Goodwin Dam is located less than 1-1/2 miles downstream. Aerial views of both dams including the West Branch Reservoir are shown on Figures 1 and 2, respectively.

Facilities Description

The important physical components of the project consist of an earth-rockfill dam and dike, chute spillway, outlet works and recreational facilities related to fishing. Pertinent data for the existing project are summarized in Table 2. A general layout of the dam and related features, together with profile and sections of the existing outlet works, appear on the "As-Built" drawings on Plates 2 and 3, respectively. For a general review of the reservoir area and its physical components, refer to Reservoir Map of the Public Use Plan, shown on Plates 4 and 5.

The dam embankment consists of compacted earth and rockfill and is approximately 1,300 feet long with a maximum height of 223 feet above streambed. The top of dam at elevation 790 feet National Geodetic Vertical Datum (NGVD) provides 24 feet of spillway surcharge and 5 feet of freeboard. The top width of 30 feet accommodates an 18-foot paved access road. The embankment slopes are 1 on 2, except for the top 10 feet, which are steepened to 1 on 1-3/4 to allow for the 30-foot top width. The dam's horizontal axis is curved in an upstream direction to provide axial compression against the abutments.

The dike, as shown on Reservoir Map, Public Use Plan, Plate 4, is similarly constructed of earth and rockfill material. It is about 1,240 feet in length with a maximum height of 54 feet and is located 2,600 feet southwest of the dam abutment along a depressed ridge.

The spillway is located in a rock cut at the northeast abutment. The approach and discharge channels are separated from the dam embankment by a ridge of unexcavated rock. The 205-foot length of the ogee-shaped weir has its crest at elevation 761 feet NGVD which is 14 feet above the approach channel. The chute has a width of 200 feet at the spillway apron and transitions uniformly to a width of 100 feet in its 850-foot length.

TABLE 2

PERTINENT DATA

COLEBROOK RIVER LAKE DAM AND RESERVOIR

LOCATION — West Branch Farmington River, Colebrook, Connecticut

DRAINAGE AREA — 118 square miles

RESERVOIR STORAGES

	Dead Storage and Sedimentation	Hartford Met. District - Water Supply Existing	Replacement	New	Fish Conservation Fall Season	Flood Control	Total at Spillway Crest
Full Pool Elevation (ft, NGVD)	596.3	641.0	643.7	701.2	708.0	761.0	761.0
Capacity (acre-feet)(net)	1,000	9,800	1,000	30,700	5,000	50,200	97,700
(inches)(net)	0.16	1.55	0.16	4.88	0.79	7.98	15.52
Full Pool Area (acres)	90	355	370	713	750	1,185	1,185

EMBANKMENT FEATURES

	Main Dam	Dike
Type	Rolled earth fill with rock slope prot.	Rolled earth fill
Length (ft)	1,300	1,240
Top Elevation (ft, NGVD)	790	790
Maximum Height (ft)	223	54
Top Width (ft)	30	30
Slopes	1 on 1-3/4 to 1 on 2	1 on 2-1/2

SPILLWAY FEATURES

Type	Chute spillway, ogee weir
Crest Length (ft)	205
Crest Elevation (ft, NGVD)	761

SPILLWAY DESIGN FLOOD

Peak Inflow (cfs)	165,000
Peak Outflow (cfs)	96,000
Maximum Surcharge (ft. above crest)	24 (El. 785 ft, NGVD)

OUTLET WORKS

Type	Circular tunnel in rock
Tunnel, Inside Diameter (ft)	10
Length of Tunnel (ft)	774
Tunnel Invert Elevation (ft, NGVD)	575
Service Gate Type	Hydraulic, sluice
Service Gate Size	Three 4' x 8'
Emergency Gate Type	Hydraulic, sluice
Emergency Gate Size	Three 4' x 8'
Downstream Channel Capacity (cfs)	3,400 (Est.)

LAND ACQUISITION

Fee Taking Elevation (ft, NGVD)	766 (5 ft. above spillway crest) or 300 ft.*
Flowage Easement Elevation (ft, NGVD)	790**

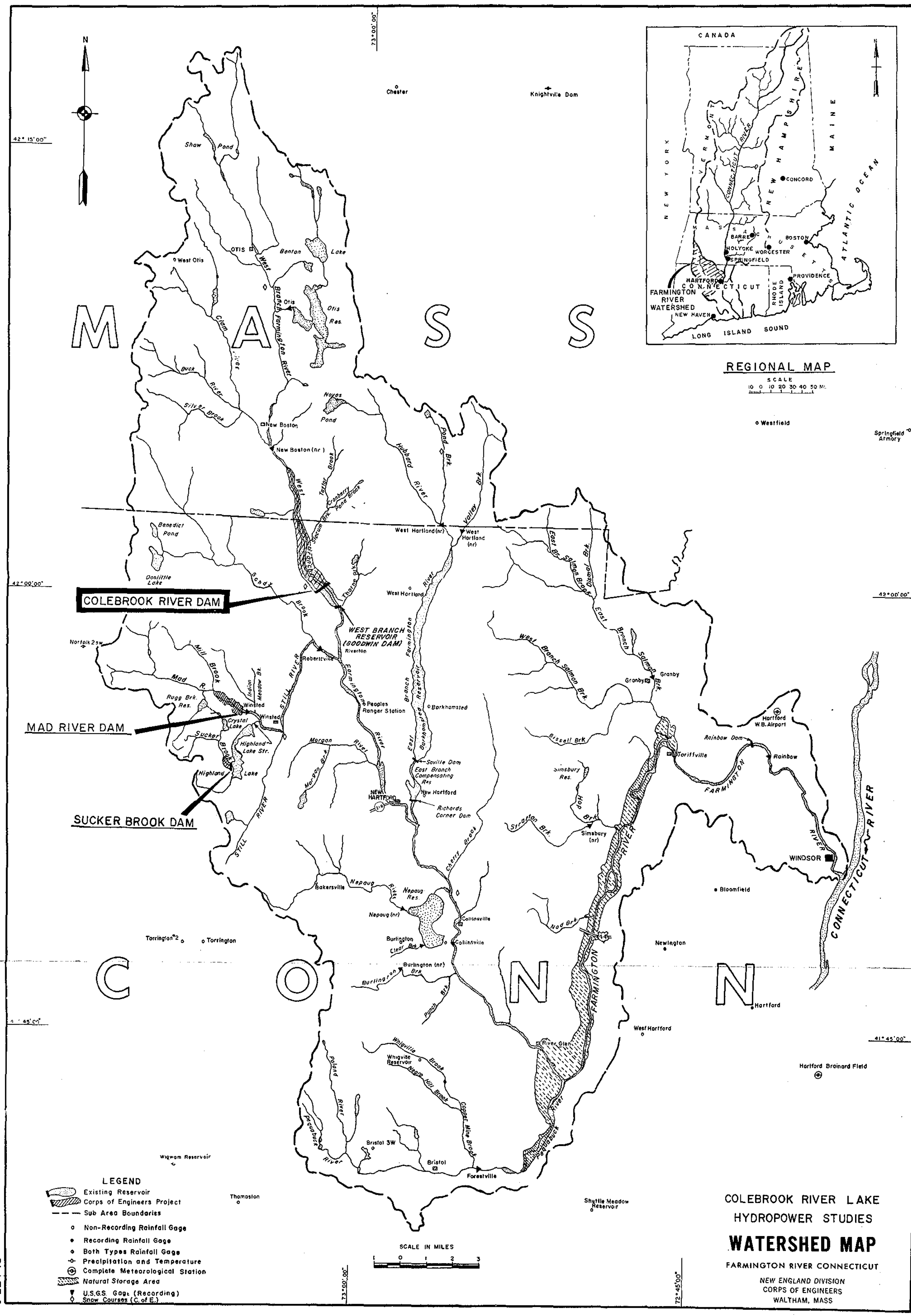
PROJECT COST — $14,100,000 (Est.)

DATE OF COMPLETION — June 1970

MAINTAINED BY — New England Division, Corps of Engineers

Notes: The total flood control storage of 50,200 a.f. includes 5,000 a.f. of joint use storage for spring shad fishery between January and June. At maximum surcharge elevation 785.0 ft, NGVD, the total storage utilized is 132,000 a.f. (20.97 in.) and area inundated is 1,510 acres.

* Horizontally from full pool, whichever is greater.
** On lands owned by Metropolitan District of Hartford County, Connecticut and Connecticut State Forest Department.



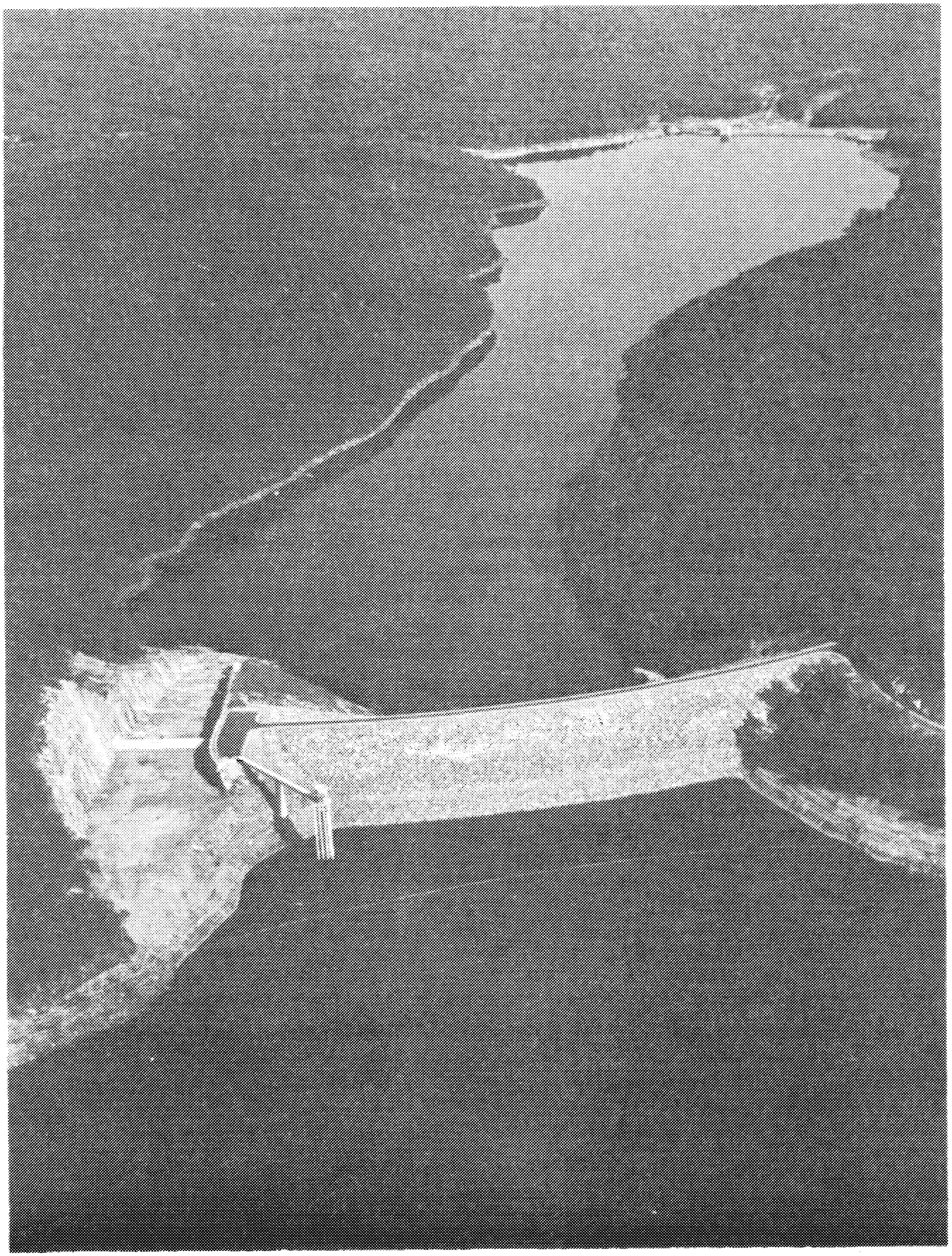
COLEBROOK RIVER LAKE
HYDROPOWER STUDIES

WATERSHED MAP

FARMINGTON RIVER CONNECTICUT

NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS

PLATE 1



VIEW OF COLEBROOK RIVER DAM (LOOKING DOWNSTREAM)

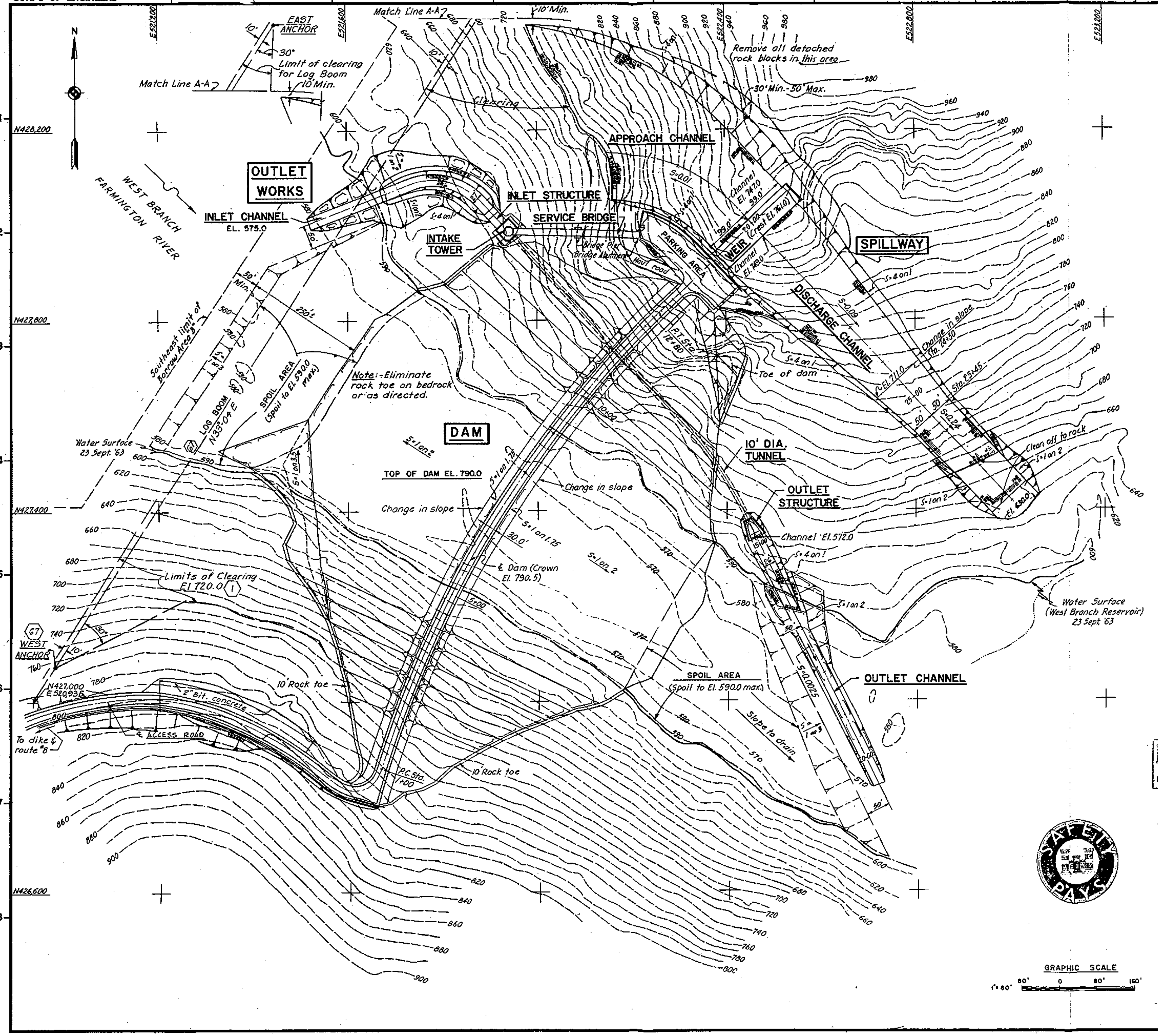
FIGURE 1

COLEBROOK-GOODWIN COMPLEX

FIGURE 2

CORPS OF ENGINEERS

U. S. ARMY



LEGEND - EXTERIOR FEATURES		
NEW	EXISTING	DESCRIPTION
20	20	Contours
x 14.7	14.7	Elevations
x—F—x		Chain Link Fence
		Paved Areas
		Tree Line
		Ditch - Grade to Drain
		Rock or Ledge Outcrop
		Limit of Contractor's Work Area
		Earth Cut and Rock Cut
		Earth Fill
		Earth Surface (Section)
		Assumed Rock Surface or Rock Cut (Section)
		Earth Cut with Rock Slope Protection
		Earth Fill with Rock Fill on Slope
—GR—		Cable Guide Rail
D.I.		Drain Inlet
• DMH		Drain manhole
—SD—		Storm Drain
—C—	—C—	Culvert
—W—		Water Line
—SS—		Sewer Line
		Swamp
	—o—E—o	Electric Line - Overhead
		Secondary Line - Overhead

GENERAL NOTES

1. Elevations refer to Mean Sea Level Datum.
2. Plane Coordinates refer to Connecticut Lambert Grid System.
3. Figures in hexagons indicate Item Numbers under which Payment will be made.
4. For limits of Contractor's Work Area, see Sheet 2.

NOTES

1. For Embankment, Plan, Profile, Sections & Details see Sheets 4, 5, and 6.
2. For Grouting Details, see Sheet 7.
3. For Spillway & Outlet Works Plan see Sheet 8.
4. For Spillway Profile, Sections and Concrete Details see Sheets 9 and 10.
5. For Outlet Works Profile, Concrete, Mechanical and Electrical Details, see Sheets 11 thru 52.
6. For Dike and Access Road Plans, Profiles, Sections and Details, see Sheets 59 thru 64.
7. For Parking Area details see Sheet 54.
8. For complete limits of Borrow Area "B" see Sheet 77.

Record Drawing

Contract No. DA-19-016-CIV ENG 65-212

REVISION	DATE	DESCRIPTION	BY
	12-22-71	Final field corrections	

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY K.E. DR. BY C.T.M. CK. BY M.B.

SUBMITTED: CHIEF, LAYOUT SECTION

REVIEWED: G. W. Hicks, PROJECT ENGINEER

APPROVED: CHIEF, DESIGN BRANCH

CONNECTICUT RIVER FLOOD CONTROL

COLEBROOK RIVER DAM

GENERAL PLAN

WEST BRANCH-FARMINGTON RIVER CONN. & MASS.

APPROVED CHIEF, ENGINEERING DIVISION

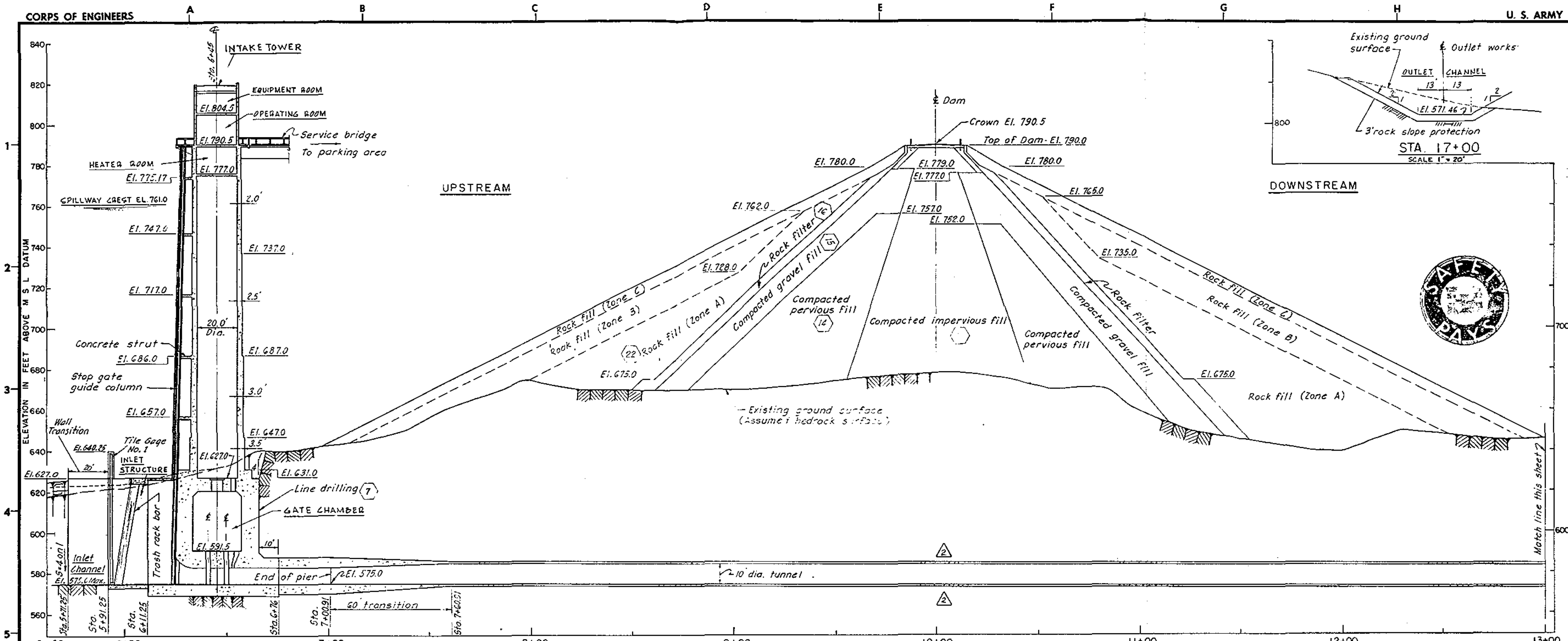
DATE JAN. 1965

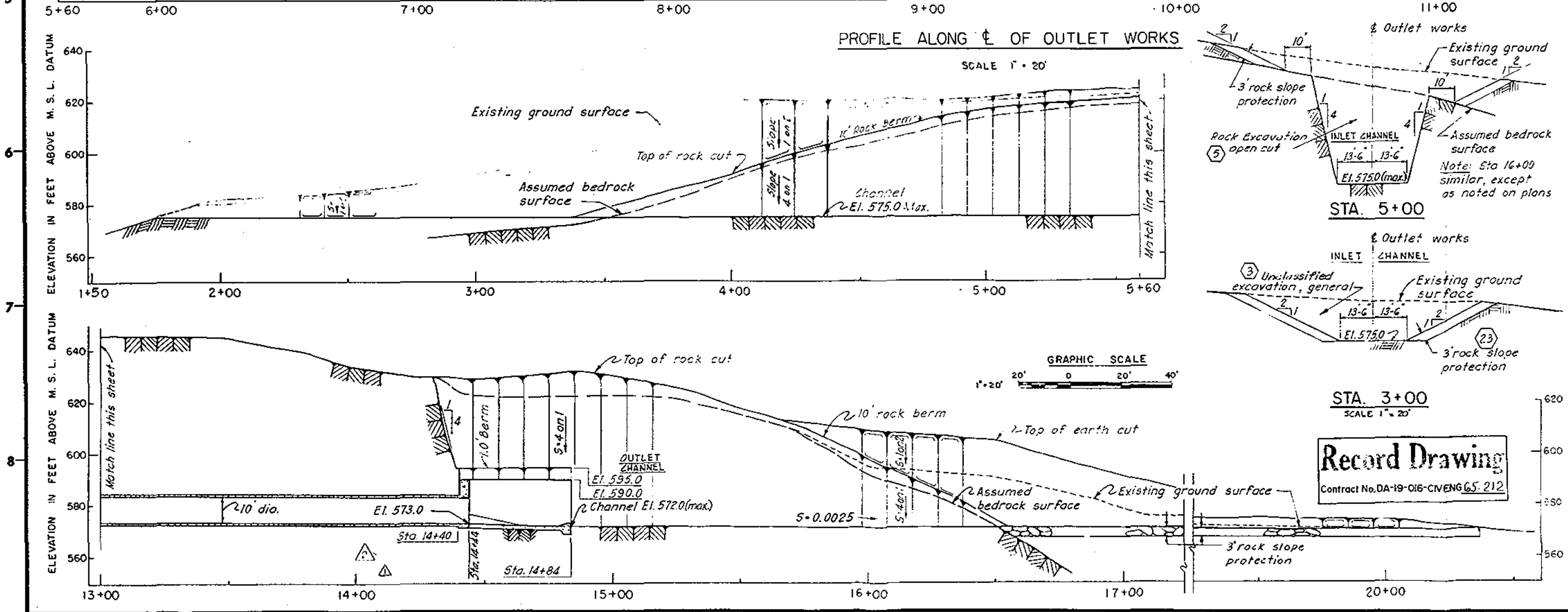
SCALE 1" = 80' SPEC. NO. CIV. ENG. 19-016-66-25

DRAWING NUMBER CON -16

SHEET 3

"AS-BUILT" PLATE 2





NOTES:

For General Notes applying to this sheet see Sheet 3

All concrete in inlet and outlet channel lining shall be paid for under Item No. 28.

All concrete from Sta. 5+91.25 to Sta 6+11.25 shall be paid for under Item No 29.

All concrete from Sta. 6+11.25 to Sta. 6+76 and to El. 631.0 shall be paid for under Item No. 32.

All concrete in intake tower between El. 631.0 and El. 775.17 shall be paid for under Item No. 33.

All concrete in intake tower above El. 775.17 shall be paid for under Item No. 34.

All concrete in tunnel between Sta. 7+60.91 and Sta. 14+44 shall be paid for under Item No. 30.

All rock excavation - open cut - shall be paid for under Item No. 5.

All rock excavation - tunnel between Sta. 6+66 and Sta. 14+40 shall be paid for under Item No. 6.

All concrete in tunnel transition between Sta. 6+76 and Sta. 7+60.91 shall be paid for under Item No. 31.

All unclassified excav, except borrow, shall be paid for under Item No. 3.

REVISION	DATE	DESCRIPTION	BY
2	7-28-65	Steel Tunnel lining and reinforcement deleted.	
1	6-8-65	Steel Tunnel lining extended to Sta. 13+84	

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY A.F.D. — DR. BY A.G. — CK. BY M.Z.

SUBMITTED: CHIEF, LAYOUT SECTION

REVIEWED: G. W. Hicks, PROJECT ENGINEER

APPROVED: CHIEF, DESIGN BRANCH

APPROVED: CHIEF, ENGINEERING DIVISION

CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK RIVER DAM
OUTLET WORKS
PROFILE AND SECTIONS

WEST BRANCH-FARMINGTON RIVER — CONN. & MASS.

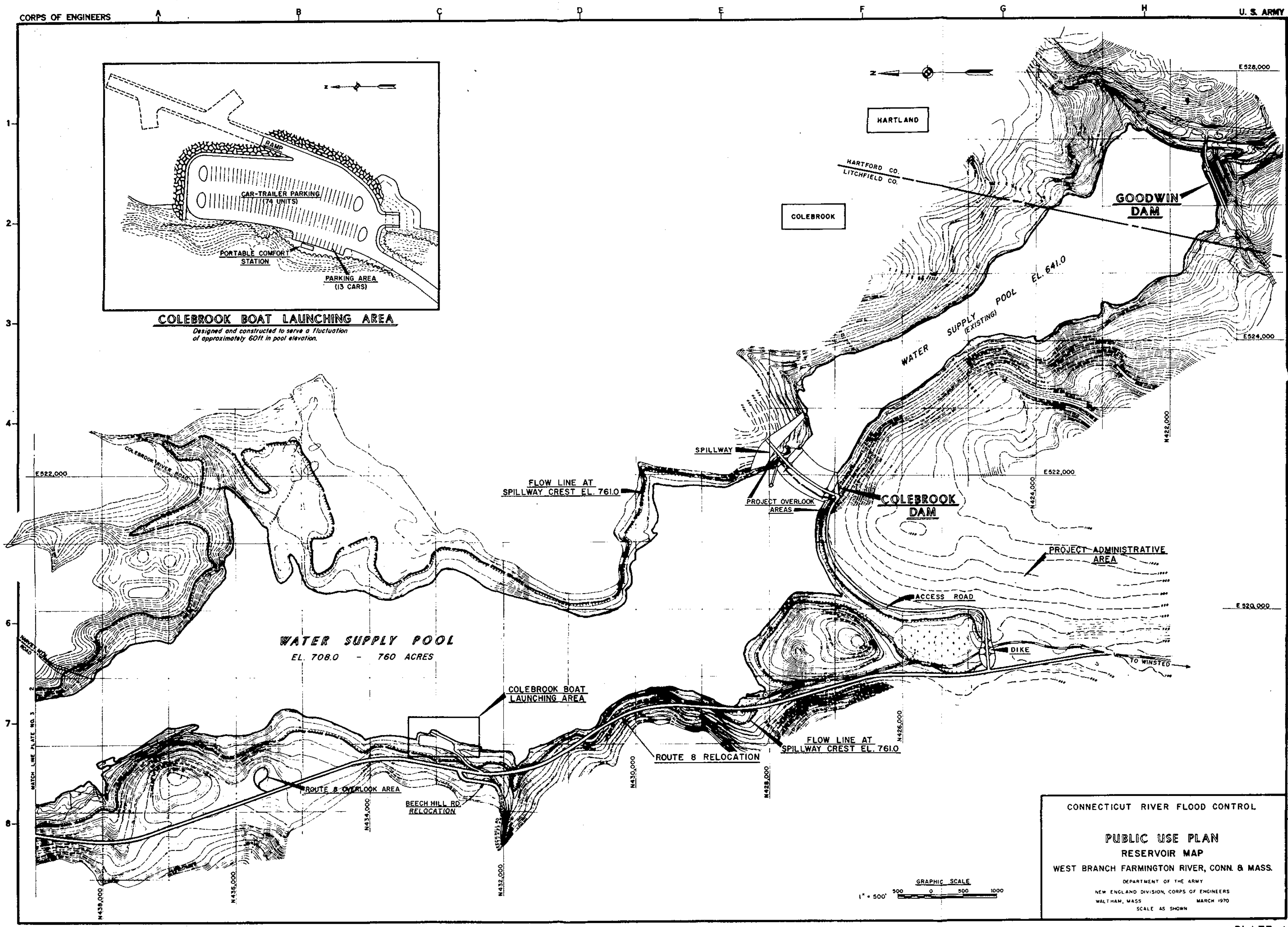
DATE JAN. 1965

SCALE 1" = 20' — SPEC. NO. CIV. ENG. 19-016-65-25

DRAWING NUMBER CON-16

SHEET 11

AS-BUILT PLATE 3



CORPS OF ENGINEERS
U. S. ARMY
COLEBROOK BOAT LAUNCHING AREA
Designed and constructed to serve a fluctuation of approximately 60ft in pool elevation.
RAMP
CAR-TRAILER PARKING (74 UNITS)
PORTABLE COMFORT STATION
PARKING AREA (13 CARS)
HARTLAND
COLEBROOK
HARTFORD CO.
LITCHFIELD CO.
GOODWIN DAM
WATER SUPPLY POOL (EXISTING) EL. 641.0
E 528,000
E 524,000
E 522,000
E 520,000
N 422,000
N 424,000
N 426,000
N 428,000
N 430,000
N 432,000
N 434,000
N 436,000
N 438,000
SPILLWAY
FLOW LINE AT SPILLWAY CREST EL. 761.0
PROJECT OVERLOOK AREAS
COLEBROOK DAM
PROJECT ADMINISTRATIVE AREA
ACCESS ROAD
DIKE
TO WINSTED
COLEBROOK RIVER ROAD
WATER SUPPLY POOL
EL. 708.0 - 760 ACRES
COLEBROOK BOAT LAUNCHING AREA
ROUTE 8 RELOCATION
ROUTE 8 OVERLOOK AREA
BEECH HILL RD. RELOCATION
MATCH LINE PLATE NO. 3
GRAPHIC SCALE
1" = 500'
500 0 500 1000
CONNECTICUT RIVER FLOOD CONTROL
PUBLIC USE PLAN
RESERVOIR MAP
WEST BRANCH FARMINGTON RIVER, CONN. & MASS.
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. MARCH 1970
SCALE AS SHOWN

PLATE 4

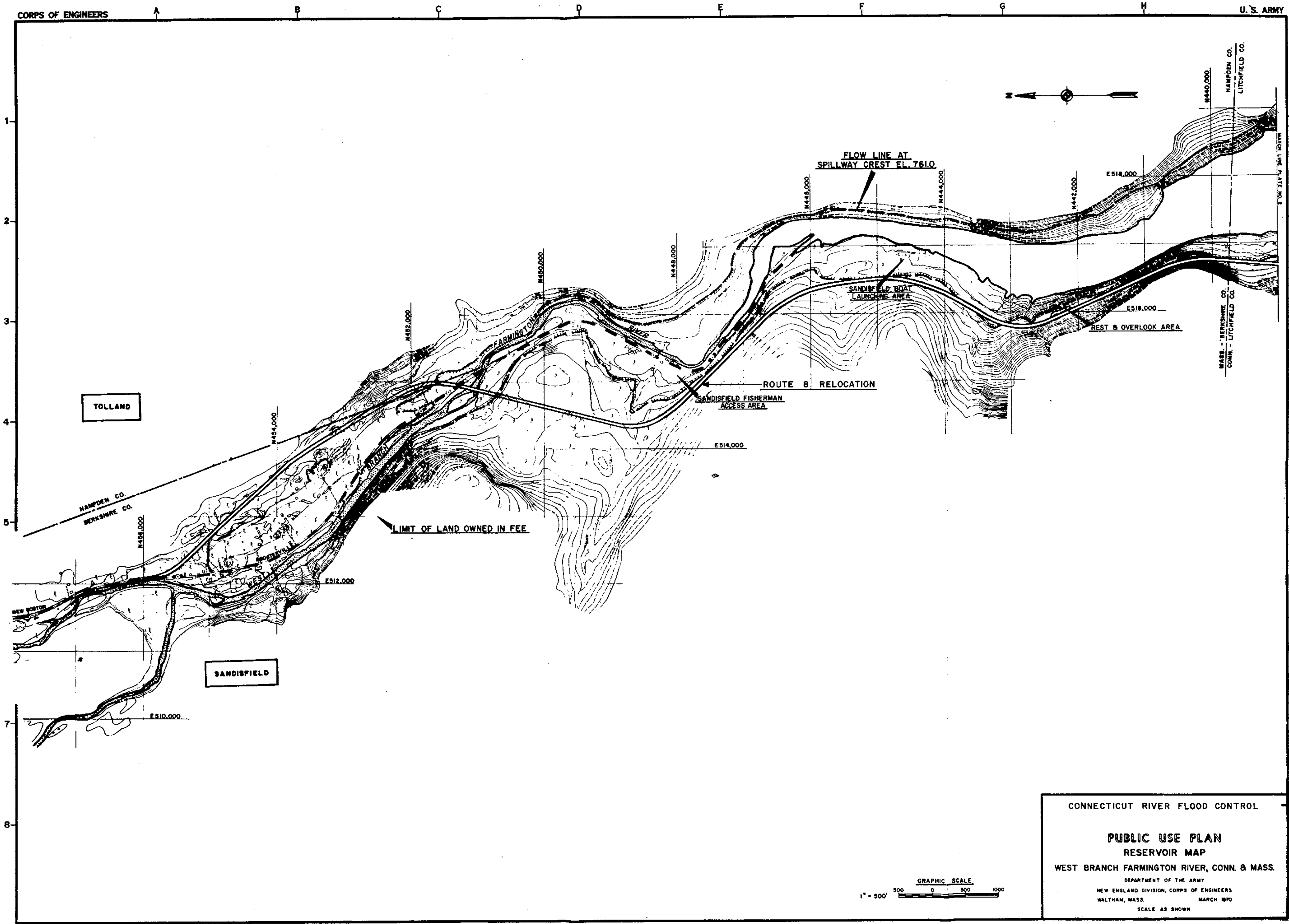

CORPS OF ENGINEERS
U. S. ARMY
FLOW LINE AT
SPILLWAY CREST EL. 761.0
SANDISFIELD BOAT
LAUNCHING AREA
REST & OVERLOOK AREA
ROUTE 8 RELOCATION
SANDISFIELD FISHERMAN
ACCESS AREA
FARMINGTON
RIVER
TOLLAND
HAMPDEN CO.
BERKSHIRE CO.
LIMIT OF LAND OWNED IN FEE
NEW BOSTON
SANDISFIELD
HAMPDEN CO.
LITCHFIELD CO.
MASS. - BERKSHIRE CO.
CONN. - LITCHFIELD CO.
N440,000
N442,000
N444,000
N446,000
N448,000
N450,000
N452,000
N454,000
N456,000
E518,000
E516,000
E514,000
E512,000
E510,000
GRAPHIC SCALE
1" = 500'
500 0 500 1000
CONNECTICUT RIVER FLOOD CONTROL
PUBLIC USE PLAN
RESERVOIR MAP
WEST BRANCH FARMINGTON RIVER, CONN. & MASS.
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. MARCH 1970
SCALE AS SHOWN

PLATE 5

The outlet works consist of a control tower with a gate chamber and operating room on the upstream side of the dam, and a 10-foot diameter discharge tunnel which passes through the dam's foundation and empties into the West Branch Reservoir at the downstream toe of Colebrook River Lake Dam. The gate structure contains three (4x8 feet) hydraulically operated vertical slide gates used for regulation purposes, with each gate having an emergency back-up gate. A monorail hoist and stop-gate are provided for emergency closure in case both service and emergency back-up gates malfunction. The invert elevations of the intake and outlet ends of the tunnel are 575 feet and 573 feet NGVD, respectively.

The authorization for the reservoir provides storage for flood control, water supply and fish conservation purposes. The storage capacity totals 97,700 acre-feet when filled to spillway crest elevation 761 feet NGVD. A summary of the reservoir storage and corresponding water surface elevation is shown in Table 2.

Colebrook River Lake Reservoir is open to recreation on a limited basis only. Recreational activities related to fishing are allowed during the fishing seasons of Massachusetts and Connecticut. All other forms of water-associated recreation are prohibited in the reservoir by State of Connecticut law, because reservoir impoundment includes storage for municipal water supply. Picnicking is not allowed on lands surrounding the reservoir; however, these lands are open to public hunting and hiking. The boat launching area, completed in December 1969, consists of two boat launching ramps, parking area and mobile comfort station.

Water Rights

The Farmington River, as shown on Plate 1, is an important source of domestic and industrial water supply for communities both inside and outside the basin. Services are provided principally by the New Britain Water Department and the Hartford MDC. The latter, a municipal corporation created by the Connecticut State Legislature, supplies the water needs for areas lying almost wholly outside the Farmington River watershed, namely, the city of Hartford and numerous nearby towns.

Due to the extension of this service to other communities and to keep pace with industrial and population growth, the Hartford MDC has developed two substantial water supply reservoirs in this watershed: Nepaug Reservoir on the Nepaug River and Barkhamsted Reservoir on the East Branch. In addition, the Hartford MDC operates two compensating reservoirs designed to regulate low flows for the benefit of existing riparian owners as compensation for the right to divert water out of the natural stream courses for water supply purposes.

The first compensating reservoir to be constructed was the East Branch Reservoir which is no longer used for stream regulation because of the construction of Barkhamsted Reservoir (Saville Dam) for water supply purposes. However, limited capacity is available for reserve storage. The second compensating reservoir is the West Branch formed by the James Goodwin Dam (formerly Hogback Dam). The former is located along the East Branch of the Farmington River, and the latter on the West Branch with its dam situated downstream of the Colebrook River Lake Reservoir. Currently, operation of the West Branch Reservoir is primarily for stream regulation purposes. During its development stage, certain agreements were entered into with riparian mill owners and others to compensate for the impact that West Branch Reservoir would have on the Farmington River. Today, those agreements are being honored with flow releases made on the West Branch of the Farmington River in Colebrook, Connecticut at either the Goodwin Dam or at the Colebrook River Lake Dam, which are jointly and respectively controlled by the Hartford MDC and the Corps of Engineers.

Under enabling legislation, the Hartford MDC must release a total of 66,600 acre-feet (21.7 billion gallons) of water annually from both reservoir complex systems, with 53,400 acre-feet (17.4 billion gallons) released between 15 May and 31 October. Also, the complex systems can impound only those inflows in excess of 150 cubic feet per second (cfs) and must maintain minimum outflow of 50 cfs.

As originally planned, the West Branch Reservoir was also considered as a diversion project whereby flows in excess of those required for downstream riparian releases would be subsequently diverted to Barkhamsted Reservoir. The diversion would be accomplished by a tunnel of which only a short length has already been constructed as part of the Goodwin Dam outlet works structure. The remaining construction phase would be completed sometime in the near future when the need for domestic water supply becomes a reality.

The contract agreement between the Federal Government and the Hartford MDC for allocated water storage space for required releases at Colebrook River Lake Reservoir is included as Appendix D. Two other outstanding riparian agreements between the Hartford MDC and various mill owners, public utilities; and Allied Connecticut Towns, Inc. are appended, respectively, as Appendices E and F. Also, a copy of the Connecticut State statutes governing the powers of the Hartford MDC regarding water is included as Appendix G.

ENVIRONMENTAL SETTING

Topography

The Farmington River Basin is oriented in a north-south direction with a maximum length of 46 miles and a maximum width of 29 miles. The upper portion of the watershed extends into the high hills of northern Connecticut and southern Massachusetts, while the lower portion is located in the Connecticut lowlands. From Farmington, Connecticut to its confluence with the Connecticut River, a distance of about 35 miles, the Farmington River flows in a general northerly course through well developed flood plains. Above Farmington, the river valley is steeper and the hills higher. Watershed elevations range from 10 feet NGVD at the mouth of the Farmington River, to 2180 feet NGVD near Becket Mountain, Massachusetts in the northern headwaters of the West Branch.

The West Branch Farmington River watershed, in the western highlands of Connecticut and Massachusetts, is a rugged, maturely dissected upland of moderate relief. It is a region of rough, irregular hills and ridges with relatively deep, steep-sided valleys. Glaciation has modified the rough topography by rounding and smoothing the crests of the hills and ridges, steepening some of the valley walls and filling the valley bottoms. Elevations within the immediate vicinity of the Colebrook River Lake Reservoir range from 570 feet NGVD at the dam to about 1300 feet NGVD at the top of the adjacent hills and ridges. A high percentage of the area is wooded and five state forests are located within 10 miles of the dam.

Geotechnical Features

A thin veneer of glacial till covers the hills and ridges of the entire study area, between extensive areas of exposed bedrock. Till also occurs locally in the valleys but generally the valleys are filled with outwash materials, mostly sand and gravel, which form relatively wide, flat flood plains and extensive terraces along the lower valley slopes.

When not masked by overburden, numerous and persistent outcrops of bedrock are found along the flanks of hills and in stream channels. Bedrock in the area consists of a Paleozoic metamorphic and igneous sequence, primarily gneiss with some schist and granitic intrusions.

Climatology

Annual air temperatures in the vicinity of the project average around 45°F. Monthly averages range from about 70°F in July to 23°F in January. Temperature extremes in the region have ranged from 102°F in the summer to -29°F in the winter. The Colebrook River Lake area can experience freezing temperatures from the latter part of September through the latter part of May.

Annual precipitation averages about 45 inches and is fairly uniform throughout the year. At Barkhamsted, Connecticut, 6 miles south of the project, variations over a 47-year period ranged from as low as 29 inches to as high as 68 inches, as indicated in Table 3. Much of the winter precipitation in the region occurs as snow with average annual snowfall ranging from near 80 inches in the headwater mountains to about 40 inches in the lower areas. Snow cover over the Farmington River Basin usually reaches a maximum depth about the first of March with an average water equivalent of approximately 2.5 inches.

Aquatic Ecosystem

As indicated earlier, the Colebrook River Lake project is located on the West Branch Farmington River and encompasses portions of both Connecticut and Massachusetts. In Massachusetts, the stretch of the river within 1,000 feet of the state line is rated Class A by the Massachusetts Water Resources Commission and, as such, is designated for use as a source of public water supply. Upstream from this reach, the river and its tributaries are designated a Class B, cold water fishery. From the state line downstream to Goodwin Dam, the river is designated Class AA by the Connecticut Department of Environmental

TABLE 3

MONTHLY PRECIPITATION IN INCHES
BARKHAMSTED, CONNECTICUT
(47 years of record through 1978)

Month	Mean	Maximum	Minimum
January	3.50	9.35	0.68
February	3.18	5.87	0.78
March	3.96	10.06	1.15
April	3.90	6.96	0.81
May	3.77	7.31	0.74
June	3.97	12.72	1.02
July	3.62	9.27	1.49
August	4.05	25.70	0.73
September	4.34	11.21	0.63
October	3.55	13.86	0.25
November	4.23	7.59	0.83
December	4.16	10.24	0.71
Annual	44.2	68.6	29.1

Protection (DEP). Class AA waters are existing or proposed drinking water supply impoundments and their tributaries. From Goodwin Dam to the confluence with the Still River in Riverton, the river is designated Class A and from that point to the confluence with the East Branch Farmington River, the rating is Class B_s. Class A and B_s waters in Connecticut are both designated for cold water fisheries including spawning and growth. The criteria associated with each of the five classifications vary considerably. However, in general terms, the standards are stringent and are designed to protect the existing and future beneficial uses of the water resource.

There are no known waste discharges to the West Branch Farmington River in Massachusetts, and the Massachusetts Division of Water Pollution Control has reported that, as of 1978, water quality conditions meet the Class A and Class B requirements of the respective reaches. Data collected by NED at the old Route 8 bridge about 2.5 miles upstream from the state line corroborate this finding with a few exceptions: nitrogen levels are relatively high, but phosphorus is usually below problem levels; the water is highly colored; the pH is often below 6.5; iron concentrations are frequently above the limit for drinking water; zinc is frequently at levels that may be dangerous to sensitive aquatic life; and mercury was twice measured at very high concentrations.

No water quality data have been collected within the Colebrook River Lake impoundment and, since the discharge from the lake is submerged by West Branch Reservoir, no discharge water quality data are available either. Consequently, no definitive statements concerning water quality conditions can be made, however, the Connecticut DEP considers both impoundments to be in consonance with their Class AA standards. The same is true for the downstream Class A and B_s reaches of the river.

The Colebrook River Lake has a capacity of 97,700 acre-feet, corresponding to a spillway crest elevation of 761 feet NGVD. Of this amount, 50,200 acre-feet are allocated to flood control with the remaining 47,500 divided between water supply (41,500 acre-feet), fish conservation (5,000 acre-feet) and dead storage and sedimentation pools (1,000 acre-feet). Flood control storage begins at elevation 708 NGVD. The area capacity curves for the Colebrook River Lake Reservoir are shown as Plate 6 and the capacity table as Plate 7. The West Branch Reservoir holds an additional 8,500 acre-feet of water supply storage behind the James Goodwin Dam, at a spillway crest elevation of 641 feet NGVD. The capacity curve is shown on Plate 8 followed by its capacity table as Plate 9.

As previously noted, the water supply storage at both the Colebrook River Lake and West Branch Reservoirs is used principally for regulation of downstream low flows for the benefit of riparian owners as part of the compensation for the right to divert water out of the Farmington River Basin for water supply purposes. The Hartford MDC, which controls this storage, is required to release 66,600 acre-feet of water from its system of reservoirs in the basin each year, with 53,400 acre-feet released between 15 May and 31 October. Also, the West Branch project is permitted to impound only those inflows in excess of 150 cfs and must maintain a minimum outflow of 50 cfs through the dam. Release of water from the fish conservation pool is made in accordance with instructions from the Fisheries Unit of the Connecticut Department of Environmental Protection (DEP). In all cases where requests by the Hartford MDC for releases to meet dowstream riparian or minimum streamflow commitments occur simultaneously with fish conservation flow requirements, the releases are first charged to the Hartford MDC storage.

The annual operation of the Colebrook River Lake/West Branch Reservoir complex comprises the filling of storage during the winter and spring runoff period, followed by an emptying of storage for flow augmentation during the summer. During the winter and early spring, the pool level at Colebrook River Lake is maintained at or below elevation 708 NGVD. The West Branch Reservoir is kept almost constantly at spillway crest elevation 641 NGVD. At the end of the snowmelt season, an additonal 5,000 acre-feet of flood control storage at Colebrook River Lake is utilized, when there is sufficient runoff, to store the runoff which is used to augment releases for downstream fisheries. This temporary infringement on the flood control storage is not used beyond June 30, which is considered to be the start of the hurricane season.

During the emptying of storage in the summer the West Branch Reservoir is normally maintained at spillway crest, while Colebrook reduces its volume of water considerably, reducing the size of Colebrook River Lake significantly, especially in dry years. In the past years, the West Branch Reservoir pool level has been considerably reduced due to withdrawals. In the fall of 1980, water levels reached approximately elevation 620 NGVD before being further drawn down to see how the reservoir would look at elevation 610 NGVD, for use in the current study.

Significant utilization of flood control storage at Colebrook River Lake has occurred 13 times since operation began in 1969. The highest storage on record reached an elevation of 739.8 feet NGVD in July 1972. About 53 percent of the storage capacity was used in this event, which is equivalent to 4.4 inches of runoff.

Annual maximum and minimum pool stages at Colebrook River Lake, by water year, for the period 1973 through 1980 follow:

Year	Maximum Pool	Minimum Pool
1973	739.8	633.3
1974	718.7	635.1
1975	721.1	646.3
1976	717.9	661.8
1977	722.0	632.4
1978	718.8	627.7
1979	729.6	611.5
1980	720.0	615.9

During significant flood storage periods the rate of drawdown of Colebrook River Lake Reservoir is normally in the range of 2 to 3 feet per day. Flood releases are controlled by NED Reservoir Control Center, in full awareness of downstream conditions. During the summer, in the interests of

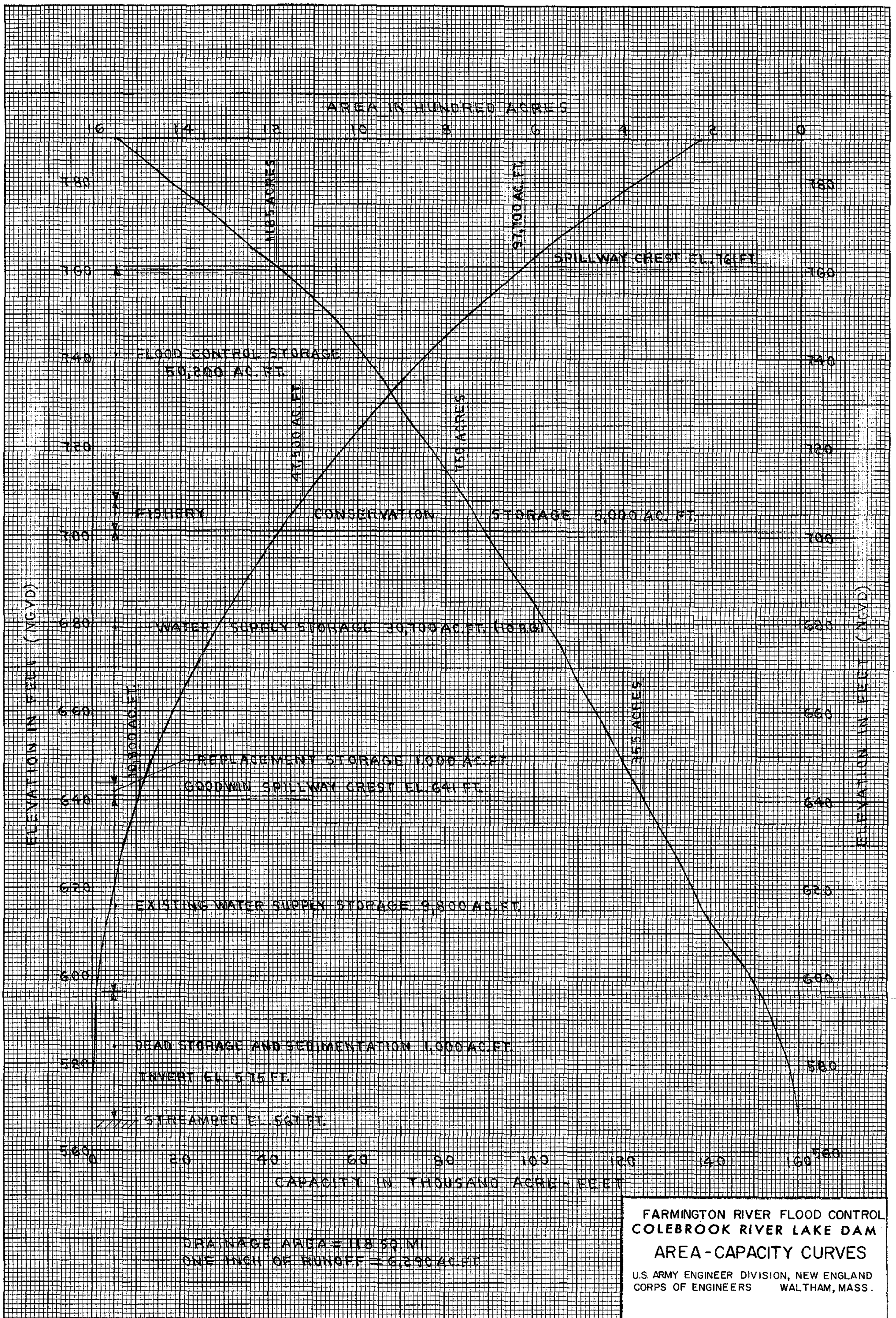
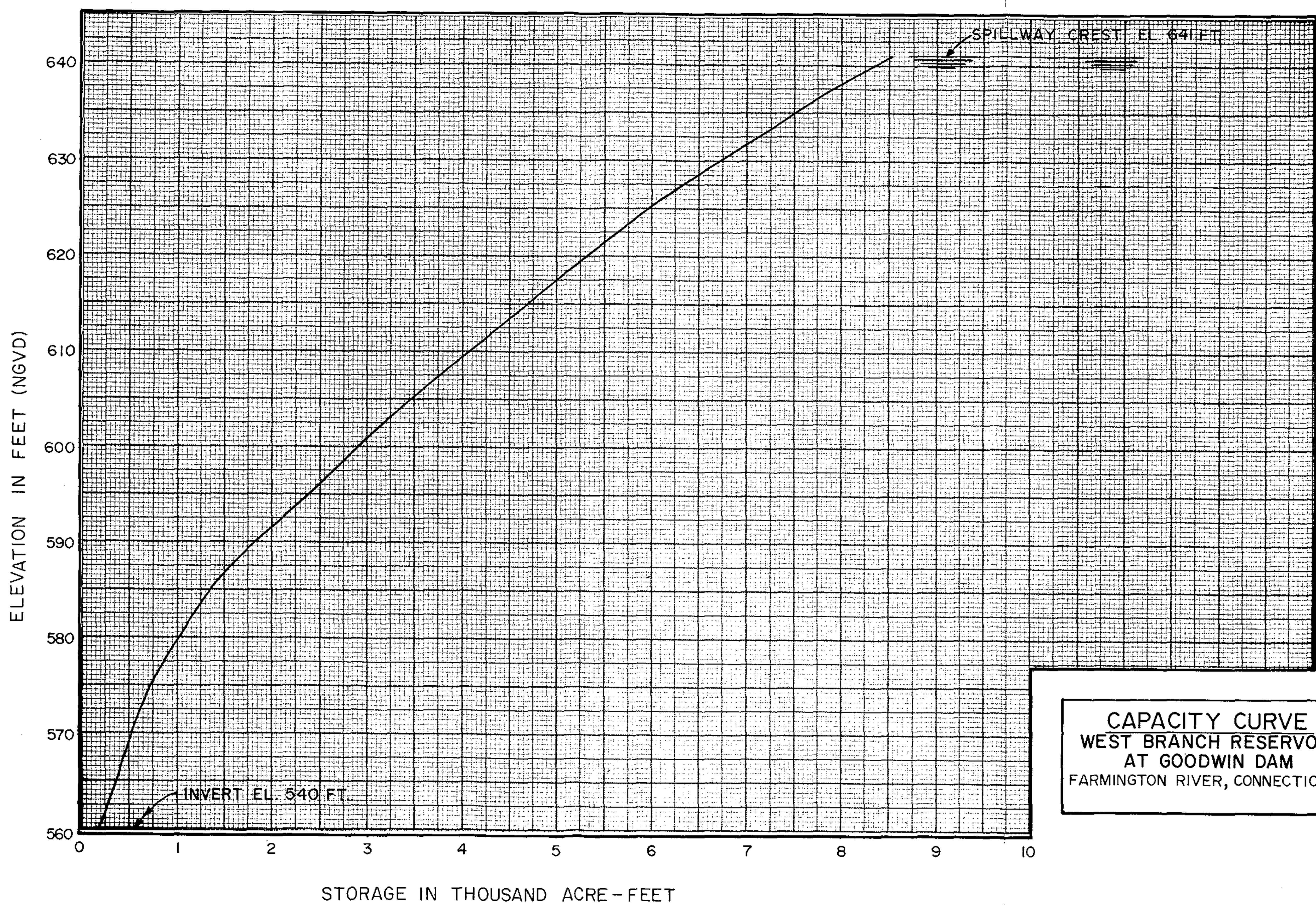

AREA IN HUNDRED ACRES
16
14
12
10
8
6
4
2
0
1185 ACRES
97,700 AC. FT.
SPILLWAY CREST EL. 761 FT.
FLOOD CONTROL STORAGE
50,200 AC. FT.
47,500 AC. FT.
750 ACRES
FISHERY CONSERVATION STORAGE 5,000 AC. FT.
WATER SUPPLY STORAGE 30,700 AC. FT. (10 B.G.)
10,800 AC. FT.
355 ACRES
REPLACEMENT STORAGE 1,000 AC. FT.
GOODWIN SPILLWAY CREST EL. 641 FT.
EXISTING WATER SUPPLY STORAGE 9,800 AC. FT.
DEAD STORAGE AND SEDIMENTATION 1,000 AC. FT.
INVERT EL. 575 FT.
STREAMBED EL. 567 FT.
ELEVATION IN FEET (NGVD)
780
760
740
720
700
680
660
640
620
600
580
560
0
20
40
60
80
100
120
140
160
CAPACITY IN THOUSAND ACRE-FEET
DRAINAGE AREA = 118 SQ. MI.
ONE INCH OF RUNOFF = 6,290 AC. FT.
FARMINGTON RIVER FLOOD CONTROL
COLEBROOK RIVER LAKE DAM
AREA-CAPACITY CURVES
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS WALTHAM, MASS.

PLATE 6

CAPACITY TABLE
COLEBROOK RIVER LAKE RESERVOIR

ELEV. (FT., NGVD)	STORAGE VOLUME IN ACRE - FEET									
	0	1	2	3	4	5	6	7	8	9
570						100	120	140	160	180
580	200	240	280	320	360	400	440	480	520	560
590	600	660	720	780	840	900	980	1,060	1,140	1,220
600	1,300	1,440	1,580	1,720	1,860	2,000	2,200	2,400	2,600	2,800
610	3,000	3,200	3,400	3,600	3,800	4,000	4,200	4,400	4,600	4,800
620	5,000	5,200	5,400	5,600	5,800	6,000	6,220	6,440	6,660	6,880
630	7,100	7,434	7,768	8,102	8,436	8,770	9,106	9,442	9,778	10,114
640	10,450	10,813	11,176	11,539	11,902	12,265	12,655	13,046	13,437	13,828
650	14,219	14,638	15,057	15,477	15,896	16,316	16,762	17,208	17,654	18,100
660	18,547	19,021	19,495	19,970	20,444	20,919	21,423	21,927	22,431	22,935
670	23,440	23,970	24,500	25,030	25,560	26,090	26,646	27,202	27,758	28,314
680	28,871	29,458	30,045	30,632	31,219	31,807	32,427	33,047	33,668	34,288
690	34,909	35,562	36,216	36,869	37,523	38,177	38,864	39,552	40,239	40,927
700	41,615	42,336	43,057	43,778	44,499	45,220	45,971	46,722	47,473	48,224
710	48,975	49,758	50,541	51,324	52,107	52,890	53,708	54,526	55,345	56,163
720	56,982	57,837	58,692	59,547	60,402	61,257	62,156	63,055	63,954	64,853
730	65,752	66,669	67,586	68,504	69,421	70,339	71,302	72,265	73,228	74,191
740	75,155	76,156	77,158	78,159	79,161	80,163	81,203	82,243	83,283	84,323
750	85,363	86,450	87,537	88,624	89,711	90,799	91,941	93,084	94,227	95,370
760	96,513	97,717	98,921	100,125	101,329	102,533	103,800	105,067	106,334	107,601
770	108,869	110,195	111,522	112,849	114,176	115,503	116,894	118,286	119,678	121,070
780	122,462	123,917	125,372	126,827	128,282	129,737	131,254	132,771	134,288	135,805

GATE INVERT ELEV. 575.0 SPILLWAY CREST ELEV. 761.0



CAPACITY CURVE
WEST BRANCH RESERVOIR
AT GOODWIN DAM
FARMINGTON RIVER, CONNECTICUT

CAPACITY TABLE OF GOODWIN DAM (WEST BRANCH RES.)
(DOWNSTREAM OF COLEBROOK RIVER LAKE)
CAPACITY IN ACRE - FEET

	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
641	8532									
640	8348	8366	8385	8403	8421	8440	8458	8477	8495	8513
639	8170	8185	8200	8219	8237	8256	8274	8292	8311	8329
638	7998	8013	8029	8047	8062	8081	8096	8114	8133	8151
637	7832	7847	7863	7881	7897	7915	7930	7949	7964	7982
636	7669	7685	7700	7715	7734	7749	7768	7783	7801	7817
635	7513	7528	7544	7559	7574	7593	7608	7623	7639	7654
634	7356	7372	7387	7402	7421	7436	7452	7467	7482	7498
633	7200	7215	7231	7246	7264	7280	7295	7310	7326	7341
632	7043	7059	7074	7089	7108	7123	7138	7154	7169	7185
631	6887	6902	6918	6936	6951	6967	6982	6997	7013	7028
630	6730	6746	6761	6776	6795	6810	6825	6841	6856	6871
629	6574	6589	6604	6620	6635	6654	6669	6684	6700	6715
628	6417	6433	6448	6463	6482	6497	6512	6528	6543	6558
627	6261	6276	6291	6307	6322	6341	6356	6371	6387	6402
626	6117	6129	6141	6156	6172	6184	6199	6215	6230	6245
625	5975	5988	6000	6015	6028	6040	6055	6070	6086	6101
624	5837	5850	5862	5877	5892	5905	5917	5932	5945	5960
623	5702	5714	5727	5742	5757	5770	5782	5794	5807	5822
622	5570	5583	5595	5610	5622	5635	5650	5662	5678	5690
621	5441	5454	5466	5481	5494	5506	5521	5533	5546	5558
620	5316	5328	5340	5352	5365	5377	5389	5401	5414	5426
619	5193	5205	5217	5230	5242	5254	5266	5279	5291	5303
618	5070	5082	5095	5107	5119	5131	5144	5156	5168	5180
617	4944	4956	4969	4981	4993	5009	5021	5033	5045	5058
616	4821	4834	4846	4858	4871	4883	4895	4907	4920	4932
615	4699	4711	4723	4735	4748	4760	4772	4785	4797	4809
614	4573	4585	4597	4610	4622	4634	4650	4662	4674	4686
613	4447	4459	4472	4484	4496	4511	4524	4536	4584	4561
612	4321	4333	4346	4358	4370	4386	4398	4410	4422	4435
611	4195	4208	4220	4235	4247	4260	4272	4284	4297	4309
610	4073	4085	4097	4109	4122	4134	4146	4158	4171	4183
609	3953	3962	3974	3987	3999	4011	4023	4036	4048	4060
608	3836	3845	3858	3867	3879	3891	3904	3916	3928	3941
607	3720	3729	3741	3753	3763	3775	3787	3799	3812	3824
606	3603	3615	3628	3640	3652	3661	3674	3686	3695	3707
605	3486	3496	3508	3520	3529	3542	3554	3566	3578	3591
604	3370	3379	3391	3404	3416	3425	3437	3450	3462	3474
603	3253	3262	3275	3287	3299	3308	3321	3333	3345	3357
602	3137	3146	3158	3170	3179	3192	3204	3216	3229	3241
601	3020	3029	3041	3054	3063	3075	3087	3100	3112	3124
600	2903	2916	2925	2937	2946	2959	2971	2983	2995	3008
599	2796	2805	2817	2830	2839	2848	2860	2873	2882	2894
598	2692	2701	2710	2722	2731	2744	2753	2762	2774	2784
597	2584	2593	2606	2615	2627	2636	2649	2658	2670	2679
596	2477	2486	2498	2507	2520	2529	2541	2550	2563	2572
595	2369	2378	2391	2400	2412	2421	2434	2443	2455	2464
594	2262	2271	2283	2293	2305	2314	2326	2336	2348	2357
593	2154	2164	2176	2185	2197	2207	2219	2228	2240	2250
592	2050	2059	2069	2081	2090	2102	2111	2124	2133	2142
591	1946	1955	1964	1976	1986	1998	2007	2019	2029	2038
590	1841	1851	1860	1872	1881	1894	1903	1915	1924	1933
589	1737	1746	1755	1768	1770	1789	1798	1811	1820	1829
588	1633	1642	1651	1663	1673	1685	1694	1706	1716	1725
587	1528	1538	1547	1557	1568	1581	1590	1602	1611	1620
586	1424	1433	1442	1455	1464	1476	1485	1495	1507	1516
585	1320	1329	1338	1350	1360	1372	1381	1393	1403	1412
584	1255	1261	1267	1274	1280	1286	1292	1301	1307	1314
583	1191	1197	1203	1209	1215	1221	1228	1237	1243	1249
582	1126	1132	1139	1145	1151	1160	1166	1172	1178	1185
581	1065	1071	1077	1083	1089	1096	1102	1108	1114	1120
580	1004	1010	1016	1022	1028	1034	1040	1047	1053	1059
579	948	951	958	964	967	973	979	985	991	997
578	893	896	902	908	915	921	924	930	936	942
577	838	841	847	853	859	862	869	875	881	887
576	783	786	792	798	801	807	813	819	826	832
575	730	733	740	746	749	755	761	764	770	776
574	681	684	691	697	700	706	709	712	718	724
573	635	638	644	648	654	657	663	666	672	675
572	592	595	602	605	608	614	617	620	626	629
571	549	552	559	562	565	571	574	580	583	589
570	506	509	516	519	525	528	534	537	540	546
569	479	479	482	485	488	491	494	497	500	503
568	451	451	454	457	460	463	466	470	473	476
567	427	427	427	430	433	436	439	442	445	448
566	390	393	396	402	405	408	411	414	420	424
565	353	356	359	365	368	371	374	377	384	387
564	319	322	325	328	331	338	341	344	347	350
563	282	285	288	295	298	301	304	307	313	316
562	246	249	252	258	261	264	267	270	276	279
561	209	212	215	221	224	227	230	233	239	242
560	175	178	181	184	187	193	196	199	203	206

the downstream fishery, the gates at Goodwin Dam are operated to release cooler waters from the lower levels of the reservoir to offset the warmer waters passing over the spillway.

The Farmington River is an important part of the Connecticut River Restoration Project for the anadromous Atlantic salmon (Salmo salar) and American shad (Alosa sapidissima). Salmon can be found at the downstream toe of Goodwin Dam, while shad usually range as close as Collinsville, about 13 miles downstream. The Farmington River is stocked by the Fisheries Unit of the Connecticut DEP with the native eastern brook trout (Salvelinus fontinalis), rainbow trout (Salmo gairdneri), an introduced western U.S. species, and brown trout (Salmo trutta), an introduced European species; 54,000 of these fish are put into the river annually. Carryover populations of wild brook trout still exist, but the majority of fisherman's take remains hatchery bred individuals. Approximately 5,400 rainbow and brown trout are stocked in Colebrook River Lake each year. The Massachusetts Division of Fisheries and Wildlife also stocks trout in, and upstream of, Colebrook River Lake.

Colebrook River Lake also contains the normal range of warmwater species, including brown bullhead (Ictalurus nebulosus), yellow perch (Perca flavescens), pumpkin-seed sunfish (Lepomis gibbosus), bluegill (Lepomis macrochirus), largemouth bass (Micropterus salmoides), rock bass (Ambloplites rupestris), and white sucker (Catostomus commersoni).

Terrestrial Ecosystem

With the exception of the dam and reservoir area, which has been cleared of trees to an elevation of 718 feet NGVD, the lands adjoining the reservoir are thickly wooded. Below the tree line shrubs, grasses, rocks and boulders surround the shoreline.

The forests in the vicinity of the project are primarily of the dense second-growth deciduous type. Common hardwood species include yellow birch (Betula lutea), white birch (B. papyrifera), black birch (B. lenta), sugar maple Acer saccharum), red maple (A. rubrum), red oak (Quercus rubra), hickory (Carya, sp.) and tulip-tree (Liriodendron tulipifera). Scattered hemlock (Tsuga canadensis), balsam fir (Abies balsamea) and white pine (Pinus strobus) can be found in the hills and valleys. Other coniferous trees include spruce (Picea, sp.), northern white cedar (Thuja occidentalis), red cedar (Juniperus virginiana) and dwarf juniper (J. communis). A variety of common northeastern ferns, shrubs and wildflowers occur in the understory.

The forests serve as habitat for a variety of resident and migrating wildlife. White-tailed deer (Odocoileus virginianus) is the only "big game" species. Other species native to the area include cottontail rabbit (Sylvilagus transitionalis), gray squirrel (Sciurus carolinensis), raccoon (Procyon lotor), muskrat (Ondatra zibethica), mink (Mustela vison) and beaver (Castor canadensis). A variety of typical northeastern small mammals, birds, reptiles and invertebrates also inhabit the vicinity of the project.

Threatened and Endangered Species

Currently, there are no Federally listed threatened or endangered species known to occur in the project area (U.S. Fish and Wildlife Service, personal communication). However, the spreading globe-flower (Trollius laxus), which is expected to be reproposed for the threatened list in the near future, has been found as close as Canaan, Connecticut, about 15 miles to the west of Colebrook River Lake. It should be looked for in calcareous wet areas.

Recreation and Natural Resources

The Colebrook River Lake, of about 760 acres with a full water supply and fish conservation pool, but experiencing annual drawdowns of up to 100 feet, still provides an excellent fishery and is heavily stocked by both the Fisheries Unit of the Connecticut DEP and the Massachusetts Division of Fisheries and Wildlife. Fishing accounts for about 14,000 visitor days of recreation each year at this project, compared to about 6,000 visitor days annually for all other recreational activities combined, not including sightseeing. Access to the lake is provided at two points: the Colebrook River Lake Boat Launching Area adjacent to Route 8, shown on Plate 4, which accounts for about 60 percent of all fishing access to the lake; and the Sandisfield Fisherman Access Area at the northern end of the project off the former Route 8, shown on Plate 5. The Colebrook River Lake Boat Lauching Area has parking for 74 cars and trailers and is capable of serving a pool fluctuation of 75 feet. The Sandisfield Fisherman Access Area has limited, informal parking and no boat ramp, but is suitable for car top boats at high pools, between elevations 708 and 725 feet NGVD.

Historic and Archaeological Resources

The Farmington valley in the vicinity of Colebrook River Lake probably served as a travel route and foraging area for prehistoric peoples, but it appears unlikely that any major settlement occurred within the present reservoir bounds. At the time of dam construction in 1965, evidence of a possible prehistoric site was found slightly north of the Spencer Bridge, in an area now below the minimum pool. This area was among those used for borrow during construction, and the site has been obliterated.

Historic occupation of the project area began in the late 18th century, but most settlement was associated with the 19th century development of the small manufacturing center of Colebrook River. Most of the cellars and other features of buildings below elevation 708 NGVD were virtually obliterated by construction activity associated with the West Branch Reservoir and Colebrook River Lake project areas, or by heavy erosion resulting from pool fluctuations. Occasional large foundations remain in partially disturbed condition. Historic sites above elevation 708 NGVD are generally in much better condition, as dense vegetation on those sites prevents erosion and deters damage from bottle hunting or other forms of vandalism. One mill site and six dwelling sites with outbuildings have been identified between elevations 708 and 761 feet NGVD. The majority of these are 19th century in construction, but all were occupied into the 20th century. None of these have been inundated by flood control pools more than three times in the past.

Socioeconomic Resources

The region encompassing the Colebrook River Lake and West Branch Reservoirs is sparsely settled and rural with a high percentage of wooded area. The towns in the immediate vicinity rely heavily upon small industry as a source of employment. Together the towns of Sandisfield and Tolland, Massachusetts had a population of slightly over 700 people according to the 1970 census. The town of Colebrook, Connecticut had a population of slightly over 1000 people in 1970. Between Colebrook and Winsted, Connecticut, along Route 8, there are a number of small industrial parks which employ area residents. Dairying, lumbering and manufacture of wood products play a smaller economic role for the people residing in this region. The Colebrook River Lake project provides increased safety along the Farmington River downstream of the reservoir, in terms of flood protection.

Future projections indicate that the population of the region will increase, but at a slow rate. Also, additional industrial facilities may be built on developable land around this area due to the flood protection afforded by Colebrook River Lake. With the number of state forests around the Colebrook River Lake area and the number of outdoor recreational opportunities enjoyed in this area, large scale industrial or residential development is not anticipated in the foreseeable future. Rather a slow, steady increase in recreational activities on a year-round basis can be expected.

Formulation of Alternatives

HYDROLOGIC CHARACTERISTICS

Watershed

The Farmington River, the fourth largest tributary area to the Connecticut River, is located in southwestern Massachusetts and north central Connecticut. The watershed lies within the counties of Berkshire and Hampden in Massachusetts and Litchfield and Hartford in Connecticut. Elevations in the watershed vary from 10 feet NGVD at the mouth of the Farmington River, to 2180 feet NGVD near Becket Mountain, Massachusetts in the northern headwaters of the West Branch Farmington River. The upper portion of the watershed extends into the high hills of northern Connecticut and southern Massachusetts, while the lower portion is located in the Connecticut lowlands.

The Farmington River, with a total drainage area of 609 square miles, is formed by the confluence of the West Branch and the East Branch Farmington Rivers in the northeast corner of New Hartford, Connecticut. Other principal tributaries of the Farmington River are Salmon, Hop and Cherry Brooks; the Pequabuck and Nepaug Rivers; and numerous smaller streams. A summary of the principal streams, their drainage areas and river mile location, in an ascending order follows:

TABLE 4

PRINCIPAL STREAMS - FARMINGTON RIVER BASIN

Stream	Drainage Area Square Miles	Miles From Mouth of Farmington River
Farmington River, at Mouth	602.0	0.0
Salmon Brook	67.3	14.3
Hop Brook	13.0	19.5
Pequabuck River	58.4	31.3
Nepaug River	31.8	42.5
Cherry Brook	13.1	43.1
E. Branch Farmington River	65.8	46.3
W. Branch Farmington River	236.0	46.3

The West Branch Farmington River is the watershed of major importance for this study. It originates at Shaw Pond on the Otis-Becket, Massachusetts town line and flows in a general southeasterly direction for about 33 miles to its confluence with the East Branch Farmington River. Colebrook River Lake and West Branch Reservoirs are located on the West Branch Farmington River at about 4 and 2-1/2 miles, respectively, upstream from the confluence with Still River at Riverton, Connecticut. At Colebrook River Lake and Goodwin Dams, the intercepted drainage areas are 118 and 120 square miles, respectively.

Located upstream of Colebrook River Lake in the headwaters of the West Branch Farmington River is Otis Reservoir, with a drainage area of 17.2 square miles. This reservoir, formerly owned by the Farmington River Water Power Company, was used to regulate flows to downstream mills. In 1967 the dam and reservoir were purchased by the Commonwealth of Massachusetts and the dam is now operated by the Department of Environmental Management for lake recreation.

As noted earlier, the West Branch Reservoir is one of four water supply reservoirs in the Farmington River Basin owned and operated by the Water Bureau of the Hartford MDC. Two of the other reservoirs, Barkhamsted Reservoir and East Branch Compensating Reservoir, are located on the East Branch Farmington River. The former has a total drainage area of 53.8 square miles and the latter, located a short distance downstream, has a net drainage area of 7.4 square miles. The fourth, Nepaug Reservoir, located on a river bearing its name, controls 31.9 square miles.

<u>Climate</u>

The Farmington River watershed has a cool semihumid climate typical of the southern New England region. Average annual temperature in the vicinity of the project is about 45°F. At Hartford, Connecticut, about 25 miles southeast of the project, monthly averages vary from about 73°F in July to about 27°F in January. Temperature extremes in the region vary from 102°F in the summer to -29°F in the winter. The Colebrook River Lake area can experience freezing temperatures from the latter part of September to the latter part of May. The mean annual precipitation in the watershed is approximately 45 inches occurring quite uniformly throughout the year. Average maximum and minimum monthly precipitation as recorded at Barkhamsted, Connecticut, located in the Farmington River Basin about 6 miles south of the project, are listed in Table 3 of Section II. Much of the winter precipitation in the region occurs as snow with average annual snowfall varying from near 80 inches in the headwater mountains to about 40 inches in the lower areas. Snow cover over the Farmington River basin usually reaches a maximum depth about the first of March with an average water equivalent of approximately 2.5 inches.

<u>Reservoir Storage</u>

Colebrook River Lake has a total controlled storage capacity of 97,700 acre-feet, with 1,000 acre-feet assigned to dead storage, 9,800 acre-feet formerly controlled by the downstream Goodwin Dam, and another 1,000 acre-feet replacement storage for the dam embankment volume placed in the West Branch Reservoir. Therefore new usable storage created by the project is 85,900 acre-feet. Of this new storage, 30,700 acre-feet is owned by the Hartford MDC and used for downstream riparian flow control and water supply. Another 5,000 acre-feet is allocated to water supply for downstream fisheries and regulated for the Connecticut DEP. The remaining 50,200 acre-feet of storage, equivalent to 7.98 inches of runoff from the 118 square miles of watershed, is allocated to flood control. It is noted, at present, that 5,000 acre-feet of the flood control storage is used seasonally (not beyond June 30) to provide additional downstream flow for the spring shad fisheries. This results in seasonal infringement on the flood control pool up to elevation 713.5 feet NGVD. Storage allocation and storage elevation data for Colebrook River Lake are listed in Tables 5 and 6. Plan view of Colebrook River Lake and downstream West Branch Reservoir are shown on Plates 4 and 5. Storage capacity curves and tables for the two reservoirs are shown on Plates 6 through 9. All these plates appear in Section II.

Streamflow

Average annual runoff from the West Branch Farmington is about 26 inches or 57 percent of mean annual precipitation. A long term U.S. Geological Survey (USGS) gaging station has recorded flows continuously since 1913 on the West Branch Farmington, upstream of Colebrook River Lake, at New Boston, Massachusetts (D.A. = 92 square miles). A shorter term USGS station records flows of the West Branch Farmington downstream of Colebrook River Lake at Riverton (D.A. = 130 square miles). Average, maximum and minimum monthly streamflows, both in cfs and inches of runoff, for the West Branch Farmington River, as recorded at the long term New Boston gage are listed in Table 7.

The Colebrook River Lake project has been operational since 1970. Therefore, the 9-year hydrologic period (1970-1978) was selected for analyzing watershed yields and the operation of the Colebrook River Lake water supply storage for downstream riparian needs. Monthly inflows to Colebrook River Lake were computed by applying a direct drainage area ratio (118/92) to the recorded New Boston flows. Monthly outflows at Colebrook River Lake were computed using inflows and monthly change in reservoir storages in the continuity relation:

$$\text{Outflow} = \text{Inflow} \pm \Delta \text{ storage}$$

The computed monthly outflows for Colebrook River Lake are listed in Table 8.

HYDROPOWER POTENTIAL

General

The hydropower potential of a volume of water is the product of its weight and the vertical distance it can be lowered. Water power is the physical effect of the weight of falling water. The function of a water power facility is to transform this gravitational potential energy into mechanical energy, by turning a turbine, for utilization in creating electrical energy via a generator. The potential rate of power generation, normally measured in kilowatts, is determined by the formula:

$$P = \frac{EHQ}{11.8}$$

TABLE 5

COLEBROOK RIVER LAKE
STORAGE ALLOCATION

Purpose	Storage (ac-ft)	Stratum Elevation (feet, ngvd)
Flood Control	50,200	761.0-708.0
Fish Conservation	5,000	708.0-701.2
Water Supply		
New	30,700	701.2-643.7
Replacement	1,000	643.7-641.0
Existing	9,800	641.0-596.3
Sedimentation and Dead Storage	1,000	596.3-567.0
Total	97,700	

TABLE 6

COLEBROOK RIVER LAKE
STORAGE-ELEVATION DATA
(D.A. = 118 Square Miles)

	Elevation (ft, ngvd)	Stage (ft)	Pool Area (acres)	Storage (ac/ft)	Runoff (inches)
Invert	567.0	0	0	0	0
Dead Storage and Sedimentation	596.3	29.3	90	1,000	0.16
Water Supply (Net)					
Existing	641.0	74.0	355	9,800	1.55
Replacement	643.7	76.7	370	1,000	0.16
New	701.2	134.2	713	30,700	4.88
Fish Conservation (Net)	708.0	141.0	750	5,000	0.79
Flood Control (Net)	761.0	194.0	1185	50,200	7.98
Spillway Crest (Total)	761.0	194.0	1185	97,700	15.52
Maximum Surcharge (Total)	785.0	218.0	1510	132,000	20.97
Top of Dam	790.0	223	--	--	--

TABLE 7

AVERAGE MONTHLY FLOWS (65 YEARS THRU 1978)
WEST BRANCH FARMINGTON RIVER NEAR NEW BOSTON, MASSACHUSETTS
(DRAINAGE AREA = 92.0 Square Miles)

Month	Average Flow		Percent of Annual Runoff	Maximum Monthly		Minimum Monthly	
	cfs	inches		cfs	inches	cfs	inches
January	177.1	2.22	8.3	430	6.5	40	0.36
February	154.7	1.86	6.9	400	4.69	46	0.59
March	295.0	4.25	15.8	947	14.19	88.5	1.33
April	413.6	5.76	21.5	828	11.07	133	1.79
May	215.0	2.90	10.8	488	6.15	62	0.87
June	127.9	1.53	5.7	478	5.76	23.9	0.31
July	84.5	0.89	3.3	290	3.60	9.3	0.06
August	97.6	0.92	3.4	1002	12.18	6	0.02
September	99.2	0.88	3.3	644	8.41	13.1	--
October	132.5	1.15	4.3	774	10.16	20	0.08
November	189.7	2.09	7.8	817	9.41	27	0.20
December	195.1	2.40	8.9	556	6.92	31	0.28
ANNUAL	181.8	26.85		341	50.2	67	10.1

NOTE: Discharge in cfs is observed at gage; Runoff in inches is adjusted for change in contents in Otis Reservoir.

TABLE 8

COMPUTED MONTHLY OUTFLOWS IN CFS FROM COLEBROOK RIVER LAKE

	J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL
1970	154	176	140	269	326	205	298	371	87	78	105	217	202
1971	89	163	302	289	260	176	201	135	348	207	156	194	210
1972	196	197	202	686	517	428	610	131	385	271	129	256	334
1973	215	383	464	490	401	235	286	231	498	107	148	173	303
1974	350	328	362	459	298	236	216	405	168	95	194	196	276
1975	184	180	341	453	302	272	250	272	235	354	387	282	293
1976	232	639	382	315	367	220	218	285	310	160	150	273	296
1977	66	55	200	641	449	140	260	456	157	138	148	397	259
1978	509	342	272	544	373	296	117	413	301				352
Mean	222	274	296	461	366	245	273	300	277	176	177	249	280

NOTE: Flows based on recorded discharges at New Boston, Massachusetts and change in storage at Colebrook River Lake where:

P = Power or capacity in kilowatts

E = Combined turbine and generator efficiencies

Q = Rate of discharge in cubic feet per second

H = Net hydraulic head in feet

With todays highly efficient turbines and generators, an average combined efficiency of 80 percent can be reasonably assumed for a typical range of operating head and discharge conditions. The potential amount of power generation over a period of time, "energy" is normally measured in kilowatt-hours and is equal to the average capacity times the duration of generation.

The potential amount of water power of any stream, river or lake is a function of: (a) the average annual streamflow, and (b) the average annual hydraulic head. Both the rate of discharge and the head are quantities which may fluctuate; therefore, it is the magnitude of these two quantities and their variability that determine the potential energy of a site and its dependability.

As previously discussed, the Colebrook River Lake Project is operated for flood control, fishery management and water supply for downstream riparian users. These operations, particularly the latter, result in considerable variation in outflow and hydraulic head at Colebrook River Lake. The water supply operation generally results in the filling of storage, with a gain in hydraulic head, during the winter and spring runoff period, followed by an emptying of storage for flow augmentation, with a resulting falling hydraulic head, during the summer low flow period. For purposes of this hydropower study, the historic operation of the project for water supply was analyzed to determine what the incidental hydropower potential of the project would be under these past operational conditions. It is noted that no effort was made to optimize the project operation for both water supply and hydropower. Such studies would be a part of more detailed studies and would likely be continually reviewed and updated following the completion of any actual hydropower installation. It is further noted that the 9-year historic hydrologic period of operation used for analysis was somewhat wetter than the long term hydrologic period of record at the New Boston gage. However, it is expected that any increase in indicated hydropower potential due to the wetter than average test period would likely be offset by potential gains in power through more optimum system operation.

Computed monthly outflows and hydraulic heads at Colebrook River Lake for the historic 9-year period of operation 1970-1978 are listed in Tables 8 and 9. Potential monthly generation was computed using representative Kaplan turbine characteristic curves, shown on Plate 10, and the computed outflows and hydraulic heads.

TABLE 9

COMPUTED MONTHLY HYDRAULIC HEAD IN FEET
(Between Colebrook River Lake and West Branch Reservoir)

	J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL
1970	0	25	32	73	72	70	47	7	44	28	37	23	38
1971	30	17	7	56	72	65	58	62	29	14	13	40	39
1972	45	49	65	74	72	85	66	65	28	15	51	54	56
1973	64	63	73	73	73	68	65	93	19	32	33	81	61
1974	67	67	72	72	71	63	50	6	41	44	41	63	55
1975	69	73	73	73	72	67	67	56	68	67	66	66	68
1976	76	66	71	74	72	63	49	53	22	27	23	3	50
1977	3	5	74	77	72	69	51	3	14	48	61	66	45
1978	69	61	66	72	72	66	61	27	3	-	-	-	55
Mean	47	47	59	72	72	68	57	41	29	34	41	50	52

NOTE: Head based on month end Colebrook River Lake elevation minus West Branch Reservoir elevation

Alternative Plans of Development

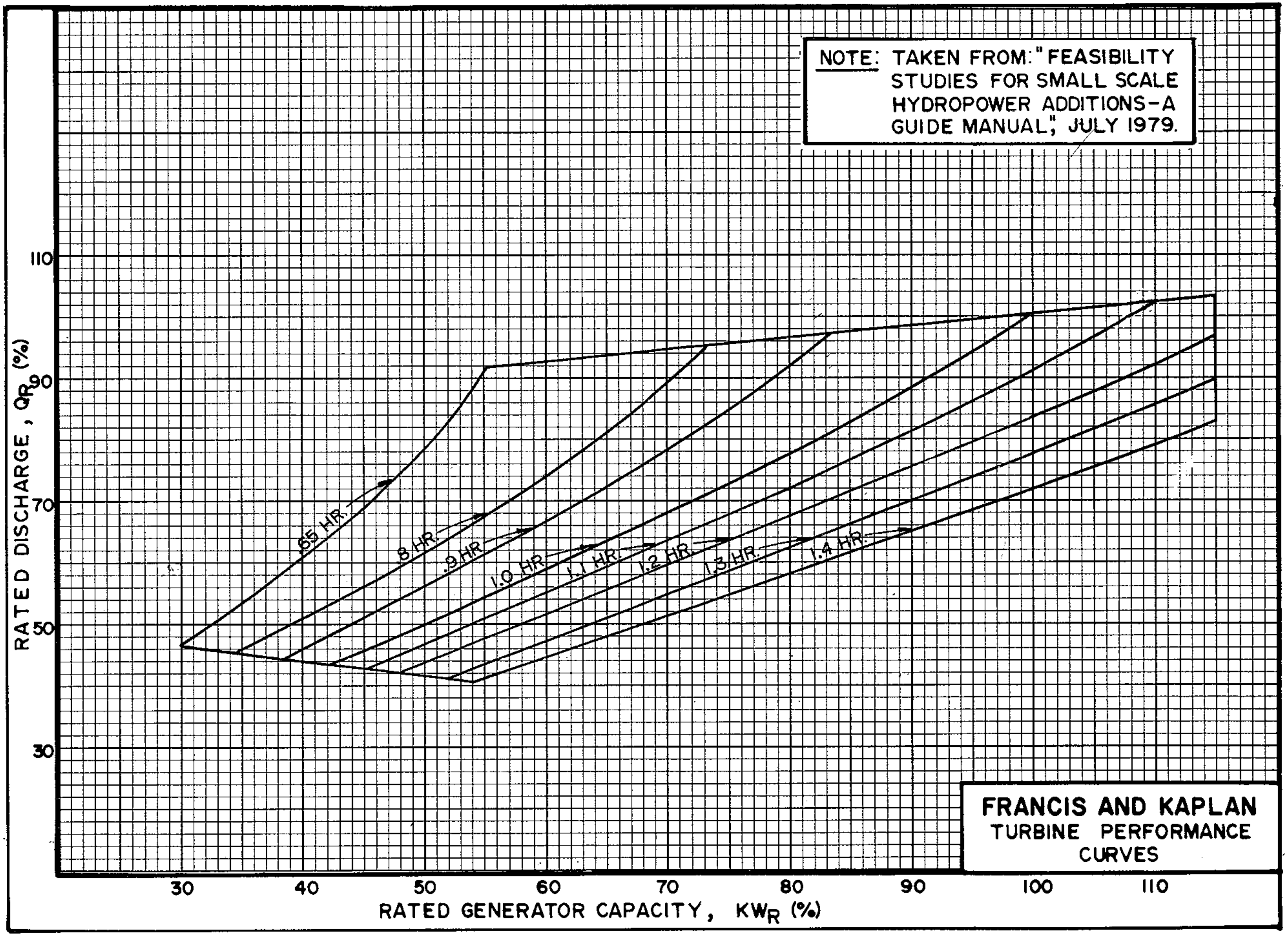
Cursory analyses were made of five alternative plans of hydropower development at Colebrook River Lake. Alternative 1 consisted of a plan for developing the hydropower potential of the Colebrook River Lake based on the outflows and heads as experienced over the 9-year historical operating period. Alternative 2 would also harness the same Colebrook River Lake outflows but there would be a reallocation of storage between Colebrook River Lake and the downstream West Branch Reservoir, thereby increasing the hydraulic head between the two projects while still meeting the same project purposes. Alternative 3 would be identical to 2 except that the hydropower facilities would be made reversible. Alternative 4 would involve Alternative 2 storage reallocation plus the addition of bascule gates on the Colebrook River Lake spillway, thereby increasing the regulated storage capacity at Colebrook River Lake for added hydropower head. Alternative 5 would be identical to 4 except that the hydropower facilities would be made reversible. The basic difference between Alternatives 1, 2 and 4 are graphically illustrated on Plate 11.

All alternatives were analyzed assuming a single hydropower unit would be sited at the downstream end of the existing Colebrook River Lake outlet with a steel liner installed for use as a penstock. It was assumed that the existing concrete conduit would require a steel liner pending further detailed investigation in subsequent study Stage 3. Therefore, the existing 10-foot diameter outlet conduit for use as a penstock would limit the installed hydraulic capacity of the hydropower facility to approximately 600 cfs. Bypass gates would be provided at the power facility for making flood control releases.

Alternative 1 - This alternative plan considers hydropower development at Colebrook River Lake based on maintaining current head differentials and existing Colebrook-Goodwin operation; that is, storage allocations and project operation for water supply would remain status quo. The only exception would occur in the flood control storage where its capability would be reduced from 50,200 to 44,600 acre-feet, equivalent to an increase in elevation of 708 to 715 feet NGVD. The increase of 7 feet in elevation would provide an incremental storage for hydropower operation. Current spillway crest and top of dam would experience no change in elevation, nor are there any structural modifications other than the steel liner as previously specified. Other project features would remain unchanged.

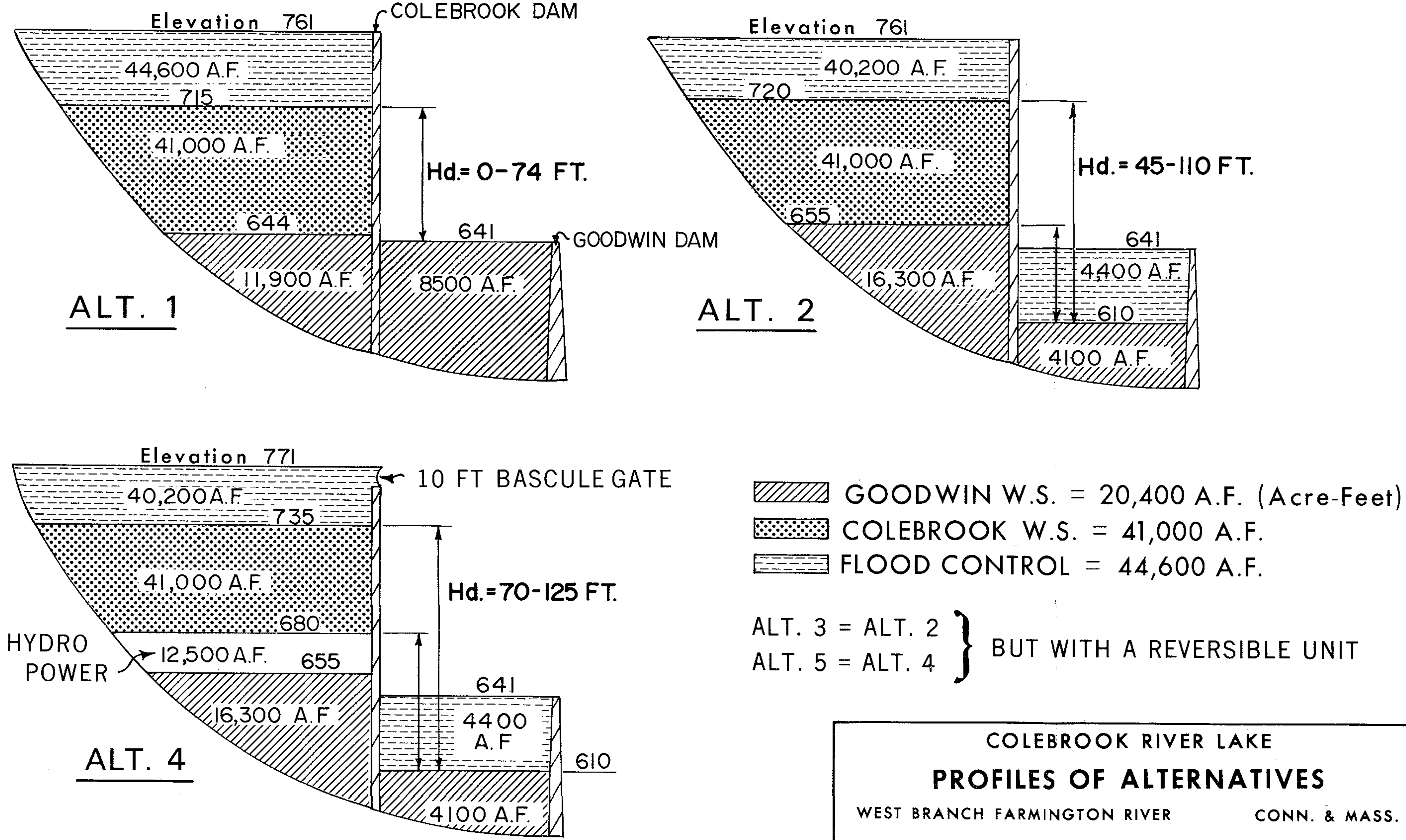
The plan, which assumes hydropower generation at Colebrook River Lake with pool levels and outflow as experienced over a 9-year historic period, was analyzed assuming a 2.5 Mw (megawatt) installation with a 60-foot design head and a resulting design hydraulic capacity of 614 cfs. This installation would be capable of harnessing nearly the full hydropower potential of the outflows from Colebrook River Lake and result in an average annual generation of 8,100 Mwh (megawatt hours). Approximate monthly and average generation for the period of analysis is listed in Table 10.

Alternative 2 - With this alternative plan, outflows from Colebrook River Lake would be the same as with Alternative 1, except there would be reallocation of 4,400 acre-feet of storage between Colebrook River Lake flood



FRANCIS AND KAPLAN
TURBINE PERFORMANCE CURVES

PLATE 10



COLEBROOK RIVER LAKE

PROFILES OF ALTERNATIVES

WEST BRANCH FARMINGTON RIVER CONN. & MASS.

NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

TABLE 10

APPROXIMATE MONTHLY POWER GENERATION
ALTERNATIVE #1 (Mwh)

	J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL
1970	-	-	-	977	1198	685	696	-	184	-	-	-	3740
1971	-	-	-	783	955	534	601	427	-	-	-	373	3673
1972	433	451	660	2203	1900	1779	2006	410	-	-	315	684	10,841
1973	699	1126	1741	1779	1505	771	896	993	-	-	-	717	10,228
1974	1170	991	1330	1632	978	621	533	-	323	208	373	638	8797
1975	291	610	1280	1645	1110	888	817	667	771	1156	1252	912	11,400
1976	899	1876	1311	1156	1349	693	534	746	-	-	-	-	8564
1977	-	-	759	2250	1650	469	655	-	-	318	526	1327	7954
1978	1762	962	909	1935	1103	958	366	-	-	-	-	-	7996
Mean	584	669	888	1596	1306	822	789	360	142	187	274	517	8132

control and the downstream West Branch Reservoir water supply. Reallocation of storages are tabulated in Table 11.

TABLE 11

REALLOCATION OF WATER SUPPLY STORAGES
(Acre-Feet)

	Behind Colebrook Impoundment			Behind Goodwin Impoundment, Downstream of Colebrook Impoundment			
Existing	11,900		+	8,500		=	20,400
Alt. 2 Change	+4,400	(loss to flood control)		-4,400	(lowers the pool-gain to flood control)		
Total Alt. 2	16,300		+	4,100		=	20,400

Total net storage of the two reservoirs for each project purpose would be unchanged. There would simply be a reallocation of storage use thus creating an increased normal differential between the two reservoirs of about 45 feet. Such a plan of storage reallocation was believed to have considerable merit because it would, in effect, serve to harness the hydropower potential of both the Colebrook River Lake Dam and the downstream Goodwin Dam with a single hydropower installation at Colebrook, rather than dual installations or the installation of a penstock extending from Colebrook River Lake Dam to downstream of Goodwin Dam. A further advantage of such a plan would be the reregulating capability provided by the downstream reservoir, permitting intermittent hydropower operation.

This alternative was analyzed assuming a 3.5 Mw installation with a 90-foot design head resulting in a design hydraulic capacity of 570 cfs. Average annual generation was computed to be about 13,600 Mwh. Approximate average monthly generation for the 9-year historic test period is listed in Table 12.

Fluctuations of the power pool through hydropower operations would be caused by the variation in loading on the plant. Maximum daily fluctuation due to "on and off" hydropower operations would generally not exceed 6 ft/day at Goodwin and 2 ft/day at Colebrook. The respective maximum rate of change would generally not exceed 0.3 to 0.5 ft/hr at Goodwin or 0.1 ft/hr at Colebrook River Lake. The rate and range for both pools would be greater during periodic freshets and flood regulations.

Neither Colebrook River Lake nor Goodwin Dams would require any structural modification in height. Their current spillway crest and dam elevation would remain as is. However, inundation of the Colebrook River Lake Boat Launching Area, as shown on Plate 4, would occur, thereby requiring the parking area to be raised at least 4 feet. In addition, 40 acres along the periphery of Colebrook River Lake Reservoir would require clearing. No

TABLE 12

APPROXIMATE MONTHLY POWER GENERATION
ALTERNATIVE #2 - (Mwh)

	J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL
1970	-	482	489	1463	1375	1063	1300	-	347	256	374	647	7795
1971	305	-	-	1372	1461	873	986	673	1106	-	-	745	7521
1972	817	837	1025	3853	2905	2606	3096	672	1233	-	567	1197	1881
1973	1103	1741	2578	2635	2228	1154	1205	1453	1334	374	507	1038	17349
1974	1777	1504	2034	2496	1693	1149	982	-	632	387	730	986	14369
1975	1002	924	1938	2491	1697	1403	1332	1283	1278	1989	1978	1489	16561
1976	1346	3157	2171	1752	2062	1071	981	1421	889	510	433	-	15794
1977	-	-	1150	3600	2523	738	1182	-	-	608	708	2097	12605
1978	2771	1527	1437	2958	2096	1513	578	1317	-				14197
Mean	1014	1130	1425	2513	2004	1285	1293	758	758	458	589	911	13889

additional land taking nor relocation of highways are envisioned at either impoundments.

Alternative 3 - This alternative plan is identical to Alternative 2 except that the hydropower installation would be reversible. The Colebrook River Lake Dam site is well suited for pump storage chiefly because both the required headwater and tailwater pools are already in existence. The economic benefit to be derived from a reversible unit would be for dependable capacity. With the 3.5 Mw installation, the minimum dependable capacity would be 2 Mw with an assumed minimum head of 50 feet.

Modification of project features, including 40 acres of reservoir clearing, as specified for Alternative 2, would remain in effect.

Alternative 4 - This alternative analyzed the feasibility of adding 10-foot high bascule gates to the 205-foot long Colebrook River Lake spillway, raising the maximum regulated pool level from elevation 761 to 771 feet NGVD. This would provide 12,600 acre-feet of added storage resulting in an average incremental increase in hydropower head of about 20 feet. This increased head would result in an annual increase in energy of 5,300 Mwh for a total potential energy output of 18,900 Mwh.

The rate and range of pool fluctuation would be similar to Alternative 2. Allocation of storages would also be identical to Alternative 2 with the exception of different resultant elevations due to the additional storage for hydropower.

The top of Colebrook River Lake would remain unchanged at elevation 790 feet NGVD. Other than structural modification to the existing spillway for adaptation of bascule gates, no structural changes to other project features are envisioned.

With spillway crest at elevation 771 NGVD, additional lands, totalling 160 acres, would have to be acquired within the upper extremities of the reservoir in Massachusetts along with about 190 acres of flowage easements of which 60 acres would be in Connecticut, with the remaining 130 acres in Massachusetts. Improvements to be purchased would involve nine residential dwellings and one commercial unit.

Mitigating measures would have to be provided for the Colebrook River Lake Boat Launching Area, the Sandisfield Fisherman Access Area, and the proposed Sandisfield Boat Launching Area. Otherwise these would be inundated and virtually unusable during high reservoir levels, thereby having a potential adverse effect on recreation. In addition, 110 acres of reservoir clearing along the periphery of the reservoir would also be required, however, the plan requires no relocation of highways other than the recreational access roads.

Alternative 5 - As previously stated, the Colebrook River Lake project is well suited for pump storage largely as both the required headwater and tailwater pools are already in existence. For that reason, the hydropower installation of Alternative 4 was analyzed with a reversible unit resulting in

Alternative 5, and therefore, the concept is identical to procedures followed in Alternative 3. Alternative 5 would have an installed capacity of 4.0 Mw and the minimum dependable capacity would be 2.5 Mw with an assumed minimum head of 65 feet.

All project features as modified to accommodate Alternative 4 would apply to Alternative 5.

Other Plans of Development - Pumped Storage

One other potential plan that could be associated with the hydropower development at Colebrook River Lake would be a high head pumped storage project previously evaluated by others some eight years ago. A better perspective on how that proposal came into existence, what its objectives are, and how it impacts on the Colebrook River Lake study has been summed up in the following paragraphs.

In July of 1973 the New England River Basins Commission (NERBC) issued a report entitled, "An Environmental Reconnaissance of Alternative Pumped Storage Sites in New England." That report was the result of a study dealing with certain economic and environmental conditions surrounding the demand and supply of peaking electric power in New England. The study was performed under the direction of the NERBC's Power and Environment Committee, and was carried out by a task force of individuals from a variety of public agencies whose responsibilities gave them an interest in pumped storage development power for New England.

The major thrust of that study was originally intended as a reconnaissance of a large number of alternative pumped storage sites in New England. However, in keeping with current social concerns, the study was enlarged to include a review of some issues related to the projected future demand for peaking power, the principles of generation mix planning, and an overview of environmental impacts of alternative peaking power generation technologies.

From an initial list of 52 technically feasible pumped storage sites, the first screening process reduced the number of sites to 14. This screening process was carried out under two criteria: insufficient generating capacity (less than 1,000 Mw), and obvious and unacceptable environmental impacts. The second step of the screening process evaluated the 14 sites on more formal grounds.

It should be noted that several characteristics associated with the latter screening process are carried out with only a modest expenditure of resources using technical and environmental information that was relatively rough and general in nature. There was no question that the resultant values could change if subsequent investigation uncovered different information. It was felt, however, that the broad types of environmental impact judgments that were made would be appropriate to the type of information available. Another point requiring emphasis is that the evaluation was limited to onsite impacts. Some thought was also given to combining site impacts and transmission impacts associated with each site, however, this analysis was found to be impossible due to available resources.

As a result of the iteration process involving a matrix array of ratings and various environmental characteristics, the 14 most viable sites were subsequently classified into three groups, namely those involving:

- Least amount of environmental impact, numbering four sites in all.

- An intermediate amount of environmental impact, numbering eight sites.

- The greatest amount of environmental impact, numbering two sites.

One site identified as Tolland Center and located within the confines of Colebrook River Lake Reservoir fell into the second classification. Its layout for development is indicated on Plate 12.

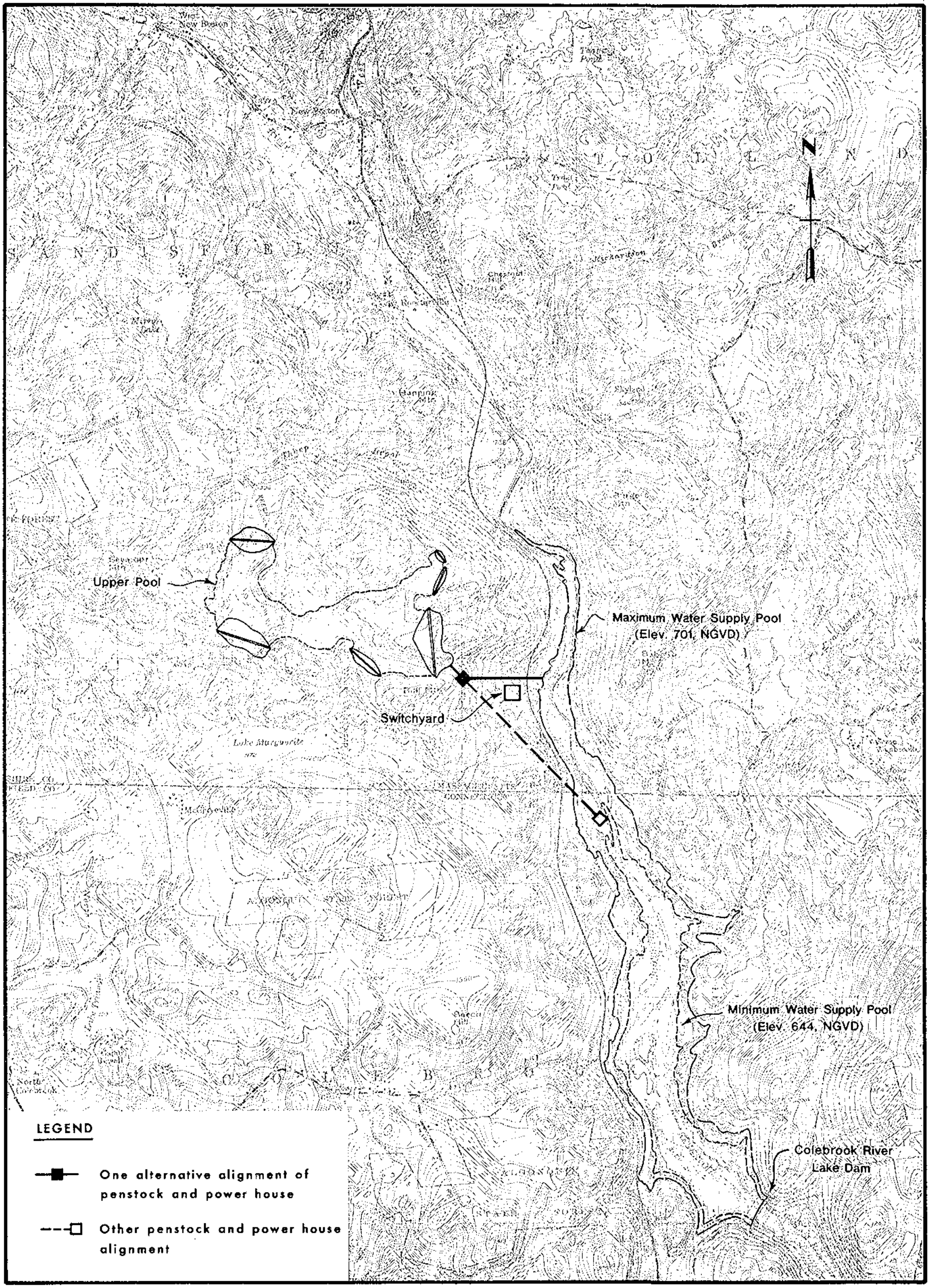
The Tolland Center site, considered a prime candidate for pumped storage, would utilize the existing Colebrook River Lake Reservoir as its lower pool. The upper pool would be formed by diking an area between Seymour and Bull Mountain, a region of swampy depressions separated by low ridges. The land in this area is in private ownership and contains several summer camps and partially abandoned roads. Commercial logging operations and some timber stand improvement work has been carried out in recent years.

The powerhouse and penstock with its two alternative layouts could be located entirely underground. From its switchyard, power would be transmitted to the power grid network at Tolland Center, located within one mile of the project.

As stated in the NERBC report the considered project would be capable of producing an approximate peaking capacity of 1300 Mw under an average head of 660 feet at full reservoir level, elevation 701 NGVD, within Colebrook River Lake. By utilizing the reserved water supply storage of the Hartford MDC, the power pool would introduce a maximum water level fluctuation of about 30 feet. As the NERBC study resources were limited, detailed evaluations of this proposal were precluded. From a cursory analysis, that pumped storage scheme would be operated in the order of 6 hours daily.

Upon closer evaluation of the proposal, in conjunction with the Colebrook River Lake Hydropower Feasibility Study, the overall Tolland Center pumped storage scheme remains valid, however, the lower pool concept as proposed by the NERBC study would provide a nondependable power output during certain critical periods of time.

Depending on the mode of operation, the Tolland Center pumped storage project would still be capable of producing peaking power. However, whether the project would be less costly than other identified viable alternatives within the New England Region would have to be determined. Such a task is considered to be beyond the scope of this study, especially since a substantial amount of energy for the pumped back operation is currently unavailable. As the public power utilites of the region are at a vantage point in the production of power and its related transmission facilities, it is considered in the best interest of the Government to simply identify the proposal as a possible viable measure to



TOLLAND CENTER PUMPED STORAGE PROJECT

PLATE 12

be pursued by non-Federal interests at their own discretion. Adverse economic impact on the Colebrook River Lake hydropower development, and the social and environmental impacts would need to be addressed if the Tolland Center pumped storage project were ever implemented.

SELECTED PLAN

The general objective of this Preliminary Feasibility Study was to determine if hydropower, as an added purpose to existing Colebrook River Lake, could be economically justified without having any major adverse impact on project features. To achieve that goal, all potential hydropower alternatives had to be explored in a brief but concise manner and in sufficient detail as to recommend an appropriate course of action.

It was also realized that for the development of any plan involving hydropower, appropriate power benefit values (capacity and energy) would be required. Those values are generally provided by FERC, who is vested with that responsibility. However, as the study had to be kept within budgetary constraints and time limitations, it became imperative to develop a methodology for evaluating the economic justification of all proposals. That methodology as developed for this study is documented in Section VII, entitled "Economic Analysis." Utilizing the results of the Economic Analysis of Tables 19 and 20 of Section VII to the five Alternative Plans, the final screening process for determining a truly selected plan was developed as described below.

Based on an annualization of project cost, the energy of 8,100 Mwh produced by Alternative 1 would have a capital recovery energy cost (CREC) of 53.8 mills/Mwh (mills per kilowatt hours). The capital recovery energy cost, obtained as the ratio of annualized cost to the energy produced, is the price at which that power produced would have to be sold for the project to be economically justified. For this analysis, it is the benefit-to-cost ratio (B/C) of unity which is attained at 53.8 mills/Kwh. Therefore, as the CREC increases the project would become more economically favorable until a level of maximization is achieved. For Alternatives 2 and 4, the energy of 13,600 and 18,900 Mwh would have a capital recovery energy cost of 34.5 and 39.3 mills/Kwh, respectively, and maximization of benefits would be derived in the same manner as Alternative 1.

It should be emphasized that the CREC values are based on today's economic condition. They exclude a relative price shift analysis, results of which appear in Table 18 of Section VII. When considering the relative price shift, the resultant values would improve the CREC, but, as all costs and benefits are relative, the end result would have no effect in improving one alternative over the other.

In preparation of this report, FERC's office of Region 1 was informally contacted with respect to hydropower benefit values. It was mutually agreed as a result of that discussion that formal submission of benefit values by FERC (particularly as they relate to capacity values) should be reserved for the next study stage.

Their criteria for capacity is very strict, and it may turn out that they intend the dependable capacity to be reflected as a credit (reduction in project costs) rather than a project benefit. Furthermore, the dependable capacity to be realized by the project is so small that it may not displace any alternative power equipment. Whether dependable capacity coincides with peak demand has yet to be determined.

It is for those reasons that capacity values were not considered for each Alternative 1, 2 and 4. By right, the same reasoning applies to Alternatives 3 and 5 involving the reversible unit schemes. However, as reversible units would add greatly to the operating flexibility, dependability and marketability of either Alternative 3 or 5, and in the event that a capacity value would be eventually allowed, an economic analysis for determining the cost that would yield a break-even point was developed. That cost per Kw of dependable capacity was derived as the quotient of the incremental cost of adding a reversible unit by its dependable capacity. For Alternatives 3 and 5, respectively, the unit cost per Kw of dependable capacity was $34.15 and $26.76 and appears in Table 20 of Section VII. Simply stated, that means if credit for dependable capacity is equal to or greater than either $34.15 or $26.76 per Kw, Alternatives 3 and 5, respectively, would be economically justified, providing there would be no net gain or loss due to pumping operations; that is, the difference in cost of peak energy for pumping and the values of added generated energy would be sufficient to offset the energy losses in operation.

A tabular summary of pertinent data involving project features, capacity, design head, energy and comparative costs for all alternatives appears in Table 13.

From an engineering and economic aspect, Alternatives 1, 2 and 4 could all be viably justified, and, if benefit credit for dependable capacity were allowed, Alternatives 3 and 5 could also be justified. Therefore, for this study, the screening process for choosing a selected plan must rely on the known social and environmental effects of the alternatives. A detailed evaluation of those impacts is documented in Section IV.

Alternative 1 would simply maintain the existing Colebrook River Lake-West Branch Reservoirs operation; that is, the hydropower potential is based on the outflows and heads as currently existing with just one exception. Flood control storage would be reduced (from 8.0 to 7.1 inches of runoff) as to provide an incremental storage for hydropower operation. This alternative would cause the least adverse impact on the environment, but, on the other hand, the total power potential of the site is inhibited. Therefore, this alternative cannot be considered as a viable candidate for the selected plan.

Alternative 2 would also harness the same Colebrook River Lake outflows but with a reallocation of storages between Colebrook River Lake and the downstream West Branch Reservoir. Though social and environmental impacts would be experienced, they are considered minor and totally within acceptable tolerances. Energy produced would be about twice as much as Alternative 1, and maximization of net benefits would possibly be achieved with this alternative. From all indications, it is apparent at this time that Alternative 2 should be chosen as the most likely candidate for the selected plan.

TABLE 13

PERTINENT DATA ON ALTERNATIVE PLANS
HYDROPOWER DEVELOPMENT AT COLEBROOK RIVER LAKE

Alternate	Features	Capacity CFS	Capacity Mw	Design Head (ft)	Annual Energy (Mwh)	Comparative Costs * Mills/Kwh	Comparative Costs ** $/Kw
1	Present operation with no major changes	614	2.5	60	8,100	53.8	
2	Storage reallocation	570	3.5	90	13,600	34.5	
3	Alternative 2 with reversible unit	570	3.5	90	13,600		34.15
4	Installation of bascule gates	590	4.0	100	18,900	39.3	
5	Alternative 4 with reversible unit	590	4.0	100	18,900		26.76

* Denotes the unit price that power produced would have to be sold in order for the project to attain a Benefit Cost Ratio of unity.

** Denotes the cost value of dependable capacity for the project to also attain a Benefit/Cost Ratio of unity, if credit for dependable power capacity were allowed.

Alternative 3 is identical to Alternative 2 except that the hydropower facility would be made reversible to provide a better operating flexibility and dependability. The impacts would be at least equal to those of Alternative 2 and possibly increase in adversity due to the pumpback operation. However, the resultant impacts are still considered minor and totally within the realm of acceptability. Currently, Alternative 3 cannot be considered as the selected plan, but it should be held in abeyance for further evaluation in the subsequent study, Stage 3. At such time, it should be determined whether or not a benefit credit for dependable capacity will be allowed.

Alternative 4 considers the addition of 10-foot high bascule gates to the Colebrook River Lake spillway, thereby increasing the storage and head for power generation. As such, the proposal would optimize the energy potential, but it would cause the most adverse social and environmental impact. With spillway crest raised 10 feet, additional acquisition of lands and improvements would be required. In addition, relocation of existing and future recreational facilities and additional acreages of reservoir clearing would also be required. Inasmuch as most of the impacts could be mitigated, the socioeconomic effects resulting from the acquisition of lands including one commercial establishment and nine homesteads in Massachusetts would cause personal inconveniences. Determination of whether or not the involved public would be receptive to such a proposal must await the public involvement program to be inititated upon release of this report in early calendar year 1981. Therefore, at this time, it would be premature to identify Alternative 4 as the selected plan. That determination would have to be made in the subsequent study phase when all public input can be fully assessed, and benefit/cost analyses are refined.

Alternative 5 is identical to Alternative 4 except that the hydropower installation is made reversible. Therefore, identical impacts would be experienced and possibly increased due to the pumpback operation. Designation of this proposal as the selected plan hinges on Alternative 4 which, as previously stated, must be currently held in abeyance pending the next study stage. At such time, it would also be determined if a benefit credit for dependable capacity is allowed.

In summation, it has been determined, at this time, that Alternative 2 should be chosen as the "most likely selected plan" pending further investigative studies in Stage 3. Although all costs, benefits and impacts have addressed all alternatives, the selected plan is the alternative upon which engineering data and drawings have been prepared, and subsequently included as part of the report. The pertinent engineering data as applicable to the Selected Plan appear in Table 14 and an illustration of the project proposal is shown on Figure 3.

The most likely selected plan would be considered principally an energy producing "fuel saving" type project, with no benefits claimed for dependable capacity. It is noted, however, that available generation could be generally forecasted on a week-to-week basis. Except during short duration flood regulation, releases are made from Colebrook River Lake per weekly at the request of the Hartford MDC and/or Connecticut Department of Environmental Protection. The Hartford MDC is required to discharge 66,600 acre-feet annually

TABLE 14

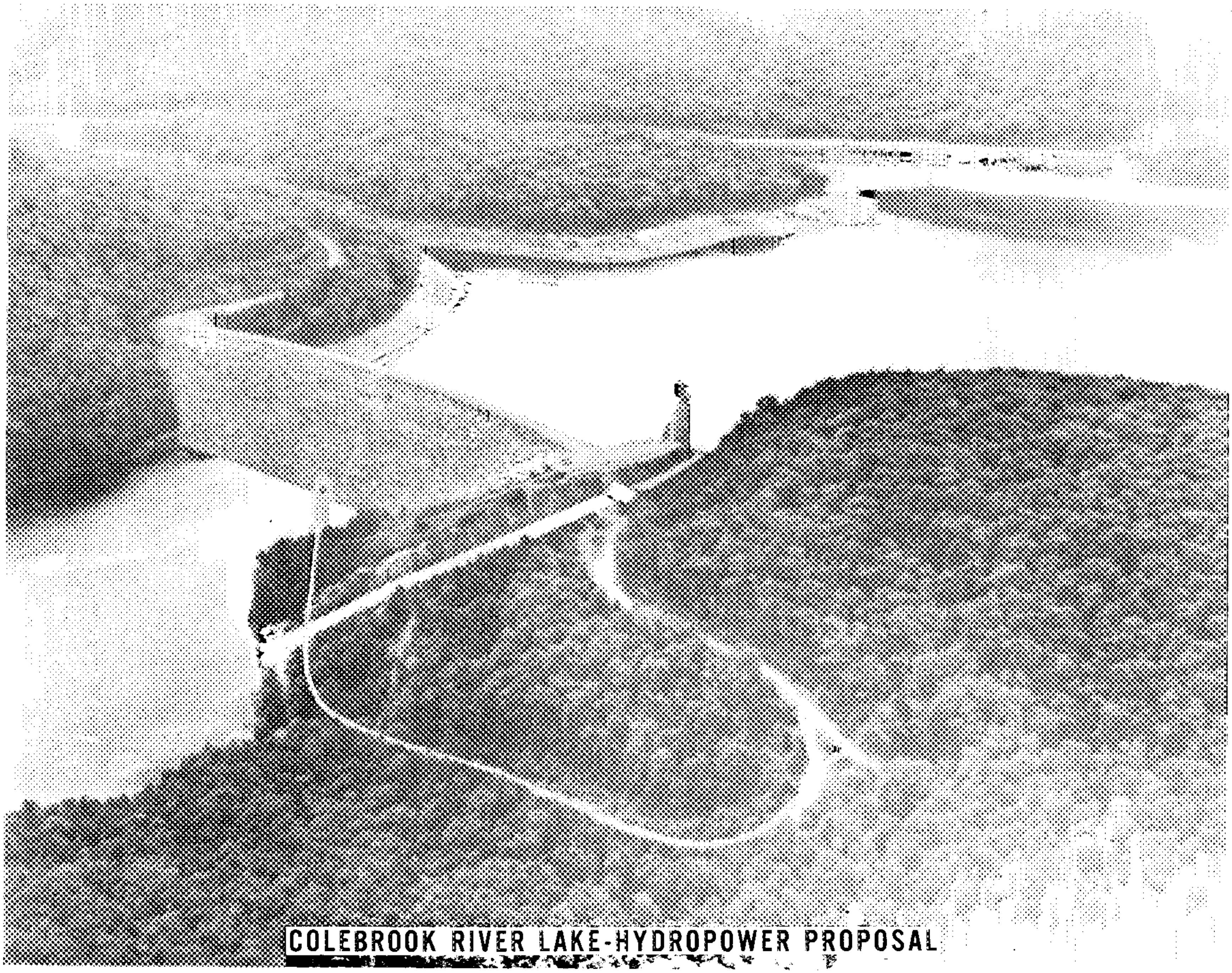
PERTINENT ENGINEERING DATA - SELECTED PLAN
COLEBROOK RIVER LAKE

1.	Number of Units	1
2.	Throat Diameter (ft)	4.6
3.	Design Hydraulic Head (ft)	90
4.	Generator Capacity (Kw)	3500
5.	Generator Type	Synchronous
6.	Hydraulic Capacity (cfs)	570
7.	Potential Annual Generation (Kwh)	13,600,000
8.	Annual Plant Factor	0.44
9.	Average Turbine/Generator Efficiency	80%
10.	Type of Turbine	Vertical Propeller with Kaplan Runner

from its system of reservoirs in the basin for use by downstream riparian owners, and 53,400 acre-feet must be discharged between 15 May and 31 October. Secondly, no less than 50 cfs outflow must be maintained at all times at the downstream Goodwin Dam and only inflows in excess of 150 cfs can be stored. During the summer months, June through October, releases from Colebrook River Lake are generally scheduled weekly and are equal to inflow plus planned releases from storage resulting in an augmented outflow and falling reservoir level. During the winter months, November through February, only inflows in excess of 150 cfs are stored, usually resulting in a gradual filling of storage. Once the water supply storage is filled, either during the winter or spring runoff period, outflow is generally maintained equal to inflow until the following summer season, except for short duration flood regulation. Average monthly outflows from Colebrook River Lake and reservoir head differentials for the 9-year historic period of analysis are listed in Tables 8 and 9. As previously stated, no effort was made in this study to develop an optimum plan of operation with hydropower as an added purpose. Hydropower was assumed an "incidental" purpose and it was assumed that the project would be operated as in the past to meet the same downstream flows. Only the change in storage allocation between Colebrook River Lake and West Branch Reservoir was considered in the interest of increased hydropower generation. Further optimization studies would be a part of any more detailed design and would likely be periodically reviewed after project completion.

With the proposed plan of operation, it is expected that the downstream West Branch Reservoir would be used as a reregulating reservoir, permitting Colebrook River Lake Project to operate in an "on-off" mode, fitting generation to power demand, within the limits of the average weekly flow requirements and resulting available head. The hydraulic capacity of the project would be in the order of 600 cfs; therefore, average daily hours of generation might vary from 7 hours per day in October and November when average flow is about 175 cfs to about 20 hours per day in April when average flow would be nearly 500 cfs. The all-season average annual plant factor would be about 44 percent or about 11 hours generation per day. Maximum rates of pool level change due to the proposed hydropower operation would be about 0.3-0.5 ft/hr in the downstream West Branch Reservoir and 0.1 ft/hr in the Colebrook River Lake. Maximum daily fluctuations as a result of hydropower operations should not exceed 6 feet in the West Branch Reservoir and 2 feet in Colebrook River Lake. Rates and magnitudes of fluctuations are considerably greater during periodic flood regulations. The existing outlet capacity at Goodwin Dam is limited to about 1,000 cfs. Therefore, during floods and high flow periods, the West Branch Reservoir will fill to elevation 641 feet NGVD to permit utilizing the spillway for the passage of high flows and the emptying of floodwaters from storage, first from Colebrook River Lake and then from the West Branch Reservoir.

FIGURE 3



COLEBROOK RIVER LAKE-HYDROPOWER PROPOSAL

Environmental Considerations of Alternatives

GENERAL

The proposal for harnessing the hydropower potential at Colebrook River Lake would involve the installation of a powerhouse downstream of the existing Colebrook River Lake Dam outlet works. Currently five alternative plans are being evaluated. They are depicted on Plate 11 and briefly summarized in the following paragraphs.

SUMMARY OF DEVELOPMENT ALTERNATIVES

Alternative Plans

Alternative 1 would consist of hydropower operation based on maintaining existing head differentials and existing Colebrook-Goodwin operation, with just one exception. This would occur in the Colebrook River Lake flood control storage where its capability would be reduced from 50,200 to 44,600 acre-feet, equivalent to an increase in elevation from 708 to 715 feet NGVD. The increase of 7 feet in elevation would provide an incremental storage for hydropower operation. Current spillway crest and top of dam at Colebrook River Lake and West Branch Reservoir would experience no change in elevation, nor are there any structural modifications envisioned.

In Alternative 2, as in Alternative 1, neither Colebrook River Lake nor Goodwin Dams would require any structural modification in height. Their current spillway crest and dam elevations would remain intact. However, the major feature would be a change in storage allocation as shown in Table 11 of Section III between Colebrook River Lake and West Branch Reservoirs. There would be 4,400 acre-feet of flood control storage taken from the Colebrook River Lake Reservoir and allocated to the West Branch Reservoir. An equal amount of water supply storage at West Branch Reservoir would be transferred to storage behind the Colebrook River Lake impoundment, thereby creating 45 feet of head for hydropower between the two reservoirs. The lowered pool at the West Branch Reservoir would also allow a reregulating capability, thus permitting intermittent hydropower operation at Colebrook River Lake.

Alternative 3 is identical to Alternative 2 except that the hydropower installation would include a reversible turbine, thus providing more flexibility and dependability for power production. The Colebrook River Lake and West Branch Reservoirs complex is well suited for pumped storage in that the required headwater and tailwater pools already exist.

Alternative 4 considers the installation of a 205-foot long, 10-foot high bascule gate at the crest of the Colebrook River Lake spillway to permit 12,500 acre-feet of added regulated storage at Colebrook River Lake thus providing for a 125-foot high head. The top of Colebrook River Lake Dam would remain unchanged at elevation 790 NGVD, and no other major project modifications are contemplated. Allocation of storages would be identical to Alternative 2 with the exception of different resultant elevations due to the additional storage for hydropower. With spillway crest at elevation 771 feet NGVD, additional lands, totalling 160 acres, would have to be purchased within the upper extremities of the reservoir in Massachusetts. It would also be necessary to purchase about 190 acres of flowage easements, of which 60 acres would be in Connecticut, and the remaining 130 acres in Massachusetts. In addition, relocation of the existing boat launching ramp, access areas and parking facilities would also be required. As in Alternatives 2 and 3, the lowered West Branch Reservoir pool would allow a reregulating capability and thus permit intermittent hydropower operation at Colebrook River Lake.

Alternative 5 is identical to Alternative 4 except that it would include a reversible turbine.

Selected Plan

The most likely selected plan as indicated earlier in this report, is Alternative 2, with the possible later replacement by Alternative 3, following further study.

With the proposed plan, including the use of the downstream West Branch Reservoir as a reregulating facility, the Colebrook River Lake Hydropower Project would operate in an "on-off" mode, fitting power generation to power demand, within the limits of flow requirements based on existing agreements and flood control constraints and resulting available head. Maximum rates of pool level change due to the proposed hydropower operation would generally not exceed 0.3 to 0.5 ft/hr at the West Branch Reservoir or 0.1 ft/hr at Colebrook River Lake. Maximum daily fluctuations as a result of hydropower operations should not exceed 6 ft/day at West Branch Reservoir or 2 ft/day at Colebrook River Lake. The anticipated rates of change at Colebrook River Lake are considerably less than those experienced during periodic flood regulations.

Since the existing capacity of the outlet works at Goodwin Dam is limited to about 1,000 cfs, the West Branch Reservoir would be allowed to fill to spillway crest elevation 641 NGVD during floods and high flow periods, to permit utilization of the spillway for the passage of high flows as well as for emptying floodwaters from storage, first from Colebrook River Lake and then from the West Branch Reservoir. Emptying of floodwaters from the West Branch Reservoir storage below elevation 641 NGVD would occur at the Goodwin Dam outlet works.

IMPACTS

Topography, Geotechnical Features and Climatology

The addition of hydropower to the Colebrook River Lake and West Branch Reservoirs complex would have no impact on the topography, geotechnical features or climatology of the area as the reservoirs are already present.

Aquatic Ecosystem

Alternative 1 involves little in the way of potential water quality impacts. Operation of the reservoir complex would be essentially the same as at present. Normal pool levels at Colebrook River Lake would be only slightly higher than usual. This would tend to strengthen stratification patterns to a small degree, with the hypolimnion being slightly larger and perhaps slightly colder. This could mean that slightly cooler water could be discharged for a longer period of time than currently occurs. The somewhat elevated pool might cause minor erosion along the shoreline and temporary small increases in suspended solids and nutrients and hence increase the biological oxygen demand of the lake's waters around the littoral areas. Primary and secondary productivity might increase slightly. Substrate instability of the littoral zone might minimally stress aquatic organisms.

Potential water quality impacts due to implementation of Alternative 2 would be experienced primarily in West Branch Reservoir and downstream and to a lesser degree in Colebrook River Lake Reservoir. By lowering the pool 31 feet and reducing the water supply storage in West Branch Reservoir by about 50 percent, detention time would similarly be decreased by about 50 percent and the impoundment would tend more towards a completely mixed condition. The decreased surface area and shorter detention time would reduce heat transfer to the water and could result in cooler temperatures downstream and in the reservoir. The storage taken from West Branch Reservoir would be added to Colebrook River Lake thereby adding another 5 feet to the normal pool elevation. The added storage and depth could further strengthen stratification patterns and increase the volume as well as decrease the temperature of the hypolimnion, over the degree expected from Alternative 1, thus allowing even cooler water to be discharged for an even longer period of time. Erosion of the shoreline and attendant impacts would be of greatest concern in the West Branch Reservoir due to its hydropower operating range in elevation from 610 to 641 feet NGVD, and also to the more frequent flood control fluctuations between elevations 610 and 641 feet NGVD, where pool levels have rarely fluctuated in the past. Shoreline erosion would also be of more concern than in Alternative 1 at Colebrook River Lake, due to the further increase in normal pool elevation.

As indicated earlier, Alternative 3 is the same as Alternative 2 with the exception that a reversible turbine would be used. Pumpback operation would cause a significant amount of mixing and would result in modified stratification and overall water quality conditions in Colebrook River Lake Reservoir. In the West Branch Reservoir, conditions would be further modified by the alternating periods of inflows and withdrawals at the upstream end of the reservoir. Shoreline erosion and related impacts would be more serious than anticipated for Alternative 2, in that they would be exacerbated in both reservoirs by the more frequent pool level changes, and the characteristic pumpback mode of several consecutive changes occurring through a single series of pool elevations.

Alternative 4 would offer significantly higher normal pool levels in Colebrook River Lake Reservoir, thus increasing the magnitude of all of the effects indicated for Alternative 2. West Branch Reservoir effects would be similar to those indicated for Alternative 2.

Alternative 5 impacts would be similar to those for Alternative 3, but with significantly higher normal pool levels in Colebrook River Lake Reservoir, would involve increased potential for shoreline erosion and attendant impacts there.

Construction of the powerhouse downstream of the Colebrook River Lake Dam would cause disruption and minor siltation in the vicinity of the upper portion of the West Branch Reservoir. It is not expected that this would stress aquatic organisms within the reservoir or downstream of it.

Further studies will involve predictive analyses of water quality conditions for the Colebrook River Lake and West Branch Reservoir system and downstream. Included will be temperature and dissolved oxygen modeling to predict modified in-lake and discharge conditions, identification of impacts and evaluation of the need for or advantage of providing selective withdrawal capability at Colebrook River Lake.

The primary aim of these studies will be to insure that the project will have no impact on these reservoirs' capability to provide for the future drinking water supply, and that it will have the least impact possible on the downstream fishery as well as the lake fishery.

Terrestrial Ecosystem

The Colebrook River Lake Reservoir has been cleared to an elevation of 718 feet NGVD for flood control and water supply pool storage. Increasing the normal full pool elevation for the alternative plans of hydropower would result in more frequent and lasting inundation of the shoreline and its associated vegetation, and would require further clearing as follows:

Hydropower Alternative Plans	Pool Elevation Feet NGVD	Additional Acres of Required Clearing
2	720	40
3	720	40
4	735	110
5	735	110

Areas uncleared and undergoing more frequent inundation would experience the killing of less flood tolerant species and a gradual shift in composition toward more tolerant species.

Resident wildlife would be displaced from the cleared and more frequently inundated areas. Most would move to higher elevations and resettle, although some might perish. The shift might cause overcrowding and further mortality in some areas where the habitat carrying capacity has been reached.

The purchase of additional lands to the new spillway crest elevation of Alternatives 4 and 5 (771 feet NGVD) would be expected to have no effect on the terrestrial ecosystem, unless a near spillway flood were to occur.

Threatened and Endangered Species

Since there are no currently listed Federal threatened or endangered species in the project area, no impacts are anticipated from implementation of the proposed project. The status of the spreading globe-flower will be carefully monitored, and specimens looked for in likely areas as the study progresses.

Recreation and Natural Resources

Fishing access to Colebrook River Lake and the pool behind Goodwin Dam would not be affected with implementation of Alternative 1 since the normal pool levels and drawdown procedures would be similar to the present situation, with pool fluctuations not exceeding 2 feet per day for hydropower operation.

With Alternatives 2 and 3 the maximum normal lake level behind Colebrook River Lake Dam would be raised to elevation 720 feet NGVD. This pool level would inundate the Colebrook River Lake Boat Launching Area (average elevation 719 feet NGVD), therefore requiring that the parking area be raised at least 4 feet and the boat ramp extended. The Boat Launching Area is located as shown on Plate 4. The Sandisfield Fisherman Access Area would not be significantly affected by the increased pool elevation, nor would the Sandisfield Boat Launching Area proposed for possible future development in the Colebrook River Lake Reservoir Public Use Plan. Both areas appear are on Plate 5. Lowering the permanent pool behind Goodwin Dam to elevation 610 feet NGVD for either Alternative 2 or 3 would have no effect on fishing, as State of Connecticut law prohibits fishing within the municipal water supply reservoir.

Implementaton of Alternative 4 or 5 would result in an increase in the Colebrook River Lake elevation to 735 feet NGVD, while the West Branch Reservoir would remain at elevation 610 feet NGVD. This would cause the Colebrook River Lake Boat Launching Area to be completely inundated for a significant period of time, particularly during the spring when fishing pressure is greatest. The Sandisfield Fisherman Access Area and the proposed Sandisfield Boat Launching Area would also be inundated and virtually unusable until the water level dropped down to approximately elevation 725 feet NGVD. Consequently, fisherman access to Colebrook River Lake could be severely limited, which in turn could have an adverse effect on the fishery resource. Lost recreation benefits would also be significant.

Historic and Archaeological Resources

There are no recorded intact prehistoric sites within the project area. An archaeological reconnaissance of the project, performed during the summer of 1980, revealed heavily eroded surfaces throughout the area below elevation 708 feet NGVD, and no evidence of prehistoric material. The extensive earth-moving associated with dam construction in 1955 and 1965, and subsequent erosion over the past 15-25 years have damaged all historic sites below elevation 708 feet NGVD to such an extent that they do not appear eligible for nomination to the National Register of Historic Places. The infrequent inundation of historic sites between elevations 708 and 761 feet NGVD does not appear to be significantly affecting their condition.

The only potential effect on historic or archaeological resources from Alternative 1 would be due to raising of the normal full pool from elevation 708 to 715 feet NGVD. However, no recorded resources exist between these elevations, and steepness of topography renders presence of unrecorded resources highly unlikely.

Alternatives 2 and 3 could affect historic or archaeological resources at Colebrook River Lake by raising of the normal full pool from elevation 708 to 720 feet NGVD. However, as with Alternative 1, no recorded potentially significant resources exist between these elevations, and unrecorded resources are unlikely to be present. The same may be said of the area that would be affected by lowering of the West Branch Reservoir pool from elevation 641 to 610 feet NGVD.

Alternatives 4 and 5 could have a major effect upon archaeological resources resulting from the raising of the normal full pool level to elevation 735 feet NGVD. This would cause frequent inundation of two 18th-19th century dwelling sites, one of which was also a tavern, and one 19th-20th century mill site, as well as an area of flood plain having moderate potential for prehistoric sites. All three of the above historic period sites are in fairly good condition and may be eligible for inclusion in the National Register of Historic Places.

The raising of spillway crest to elevation 771 feet NGVD would require removal of several dwellings and related structures, some of which are 19th century in date, in the community of Roosterville. If Alternatives 4 and 5 are pursued further, it is recommended that assessment of the National Register significance of the historic period sites and structures noted above be performed in conjunction with the subsequent Stage 3 of project planning.

Alternatives 4 and 5 would be identical to Alternatives 2 and 3 in the lack of effect from lowering of the West Branch Reservoir pool.

Socioeconomic Resources

The socioeconomic impacts of hydropower development at Colebrook River Lake can be divided into two categories: construction and post-construction.

The impacts of the construction activity would be temporary in nature, with increased noise and dust at the construction site and additional traffic on roads such as Route 8 during the actual construction period being expected.

The primary post-construction effect of the proposed project would be the creation of a hydropower facility capable of generating electrical power. Under the authority of Section 5 of the 1944 Flood Control Act, an appropriate Federal Marketing Agency to be established for the area at some future time, would have the final say as to the disposition of this power. The addition of hydropower as a project purpose is consistent with current national energy policy. Only Alternatives 4 and 5 would have significant additional socioeconomic effects, as a result of the required acquisition of an additional 160 acres of land and the purchasing of one commercial and nine residential properties. These could include the personal inconveniences associated with the permanent relocation of the commercial establishment and homesteads involved, plus an annual property tax loss of approximately $5,000 at Sandisfield, Massachusetts.

These impacts will be examined further as the study progresses.

Project Features and Costs

GENERAL

The adaptation of the Colebrook River Lake project as a hydropower installation involves the modification or alteration of some existing project facilities and the addition of other elements required for the production of electric power. Numerous components of the existing facilities require minor retrofitting operations while others are oriented to new design concepts. For a better perspective of those requirements for implementing the project features and for developing the project costs, a descriptive coverage is provided in the following text, and is applicable to all five alternatives unless specified otherwise.

A general layout of the hydropower proposal together with a centerline profile appears on Plates 13 and 14, respectively.

DAM AND SPILLWAY MODIFICATION

From observations made during current site visits, the Colebrook River Lake Dam embankment is in excellent condition. Embankment stability analyses made during design show that the embankment meets current criteria for stability with reservoir drawdown and fluctuation. Both slopes of the embankment consist of rockfill face with a 10-foot wide zone of selected large rock fragments, which is considered more than adequate to withstand wave action. The Goodwin Dam embankment is also in good condition. Preliminary stability analyses indicate the embankment meets current criteria for stability with reservoir drawdown and fluctuation. The upstream slope consists of a rockfill face with a 3-foot layer of riprap below elevation 615 feet NGVD and a 5-foot layer above that elevation, which is considered adequate to withstand wave action. Therefore, modification of either dam embankment is considered unnecessary to assure its integrity with the proposed hydropower pool operation.

The reservoir shoreline between Colebrook River Lake and Goodwin Dams is characterized by shallow bedrock surface with overburden consisting principally of sand and gravel. The pool fluctuations due to the proposed hydropower operations are expected to cause minor sloughing of the shoreline overburden in limited reaches during the first 3 years of operation which will stabilize. Preventive measures against sloughing are considered unnecessary.

Other than the construction of an access road across its discharge channel, the spillway would also remain intact for Alternatives 1, 2 and 3. For Alternatives 4 and 5 alteration of spillway weir for adaptation of bascule gates would be necessary. Bascule gates, 10 feet in height, would be added to the 205-foot long spillway. They would be installed on top of the concrete weir crest with pivotal axis mounted on three separate concrete piers built into the downstream face of the existing weir, and outer pivotal axis along modified abutment walls. Gate operation, fully automated, would be lowered at a specified time for effective discharge of emergency floodflows at a predetermined reservoir level.

An access road, as shown on Plate 13, approaching the powerhouse from the northeast would cross the spillway channel on the downstream side at about 700 feet from the concrete weir. The surface of the access road would be approximately four feet above flood storage level (elevation 645 feet NGVD) of the West Branch Reservoir. This spillway crossing would consist of one to two feet of gravel bedding with a 20-foot unpaved width. As an occurrence of a washout due to spillway discharge, considered to be a 50-year event, is anticipated, provisions for occasional reconstruction of the access road in this location is considered to be cost effective.

ACCESS ROAD

In total, nine possible routes for an access road were studied in detail and compared. Those alternatives included an 8,000-foot access approaching from the east side originating at the Goodwin Dam; approaching from the northeast; approaching from the west and crossing the face of the dam at different slopes; winding down from the parking lot at the crest of the dam; and a tower/elevator system similar to the intake structure.

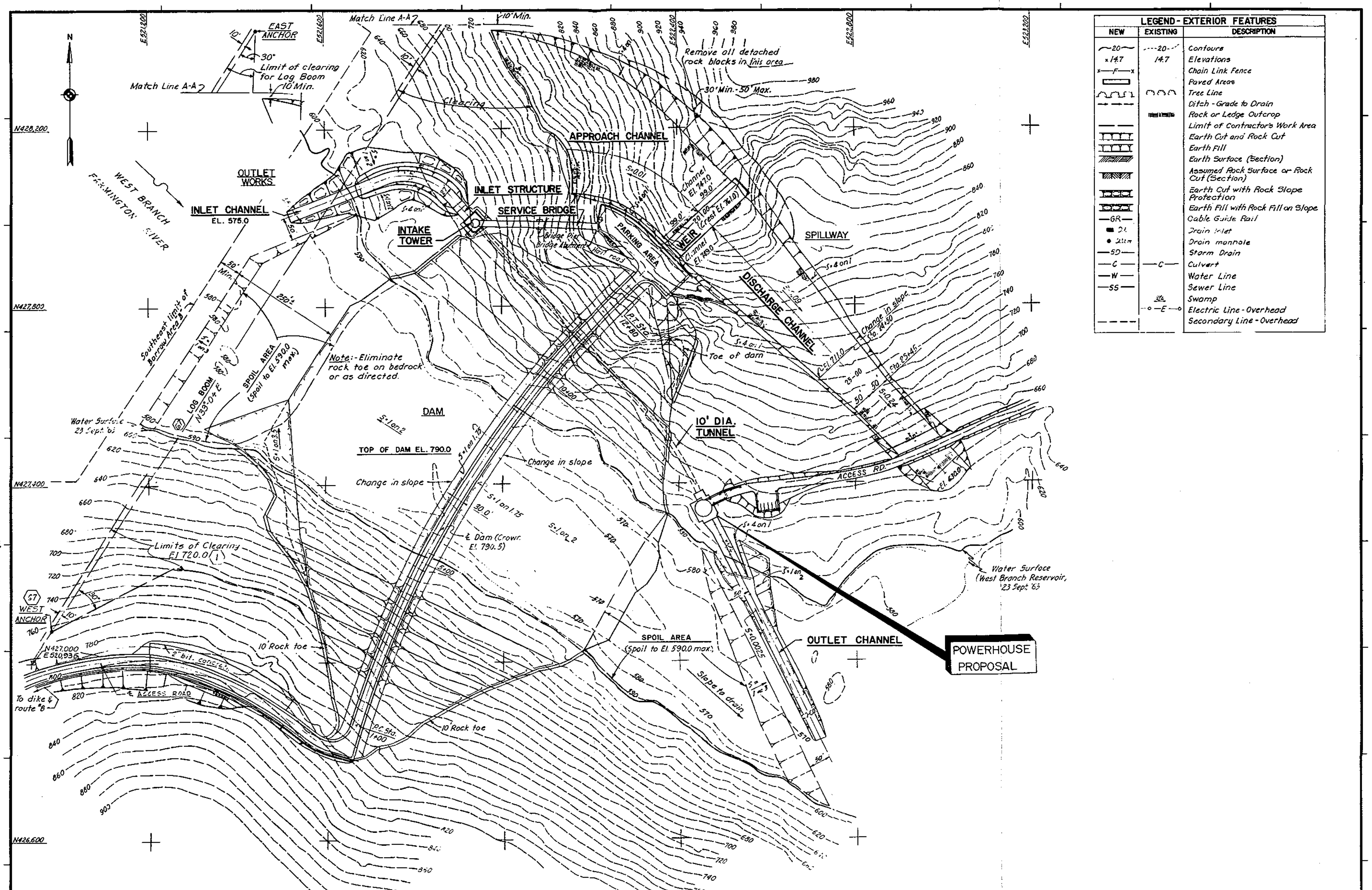
After thorough investigations including a site visit, and inasmuch as occurrence of a washout due to spillway discharge could be expected on a rare occasion, the approach from the northeast, as shown on Plate 15, proved to be cost effective. Along this route, 1-1/2 miles of existing road from the north needs minor improvement with 6 inches of gravel to bring it up to par. The final 1,200 feet of new construction would require some cut and fill along the existing right-of-way, with a foot of gravel and bituminous paving. Approximately 600 feet of that latter distance would be at a 10 to 12 percent grade in the vicinity of the spillway. The access road would be located mostly on Hartford MDC and partially on Government lands.

Although driving distance from the operating quarters of Colebrook River Lake Dam to the power station located at the outlet structure via the access road is 11 miles, after the construction stage is completed, the access road should be sparsely used. Normal foot access would be provided by a 4-foot walkway constructed from the parking lot on the east side of the dam to the powerhouse.

INTAKE STRUCTURE

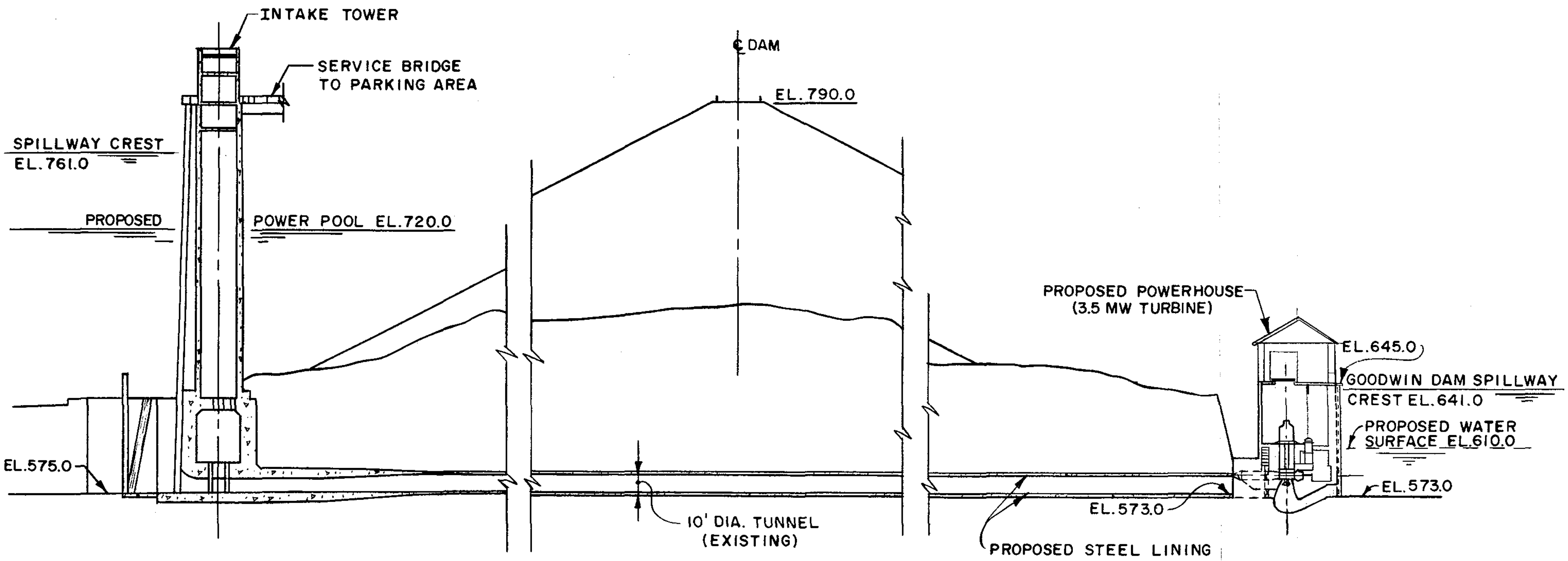
The intake works consist of a dry well control tower constructed of reinforced concrete and founded on bedrock, an operating house serviced by an access bridge, a gate chamber for regulating storage and flow releases through the outlet conduit, and other related features required for the functional operation of the project.

The gate structure contains three (4 x 8 feet) hydraulically operated vertical slide gates used for regulation purposes with each gate having an



COLEBROOK RIVER LAKE
HYDROPOWER STUDIES
POWERHOUSE SITE PLAN
NORTH BRANCH FARMINGTON RIVER CONN. & MASS.
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE 13



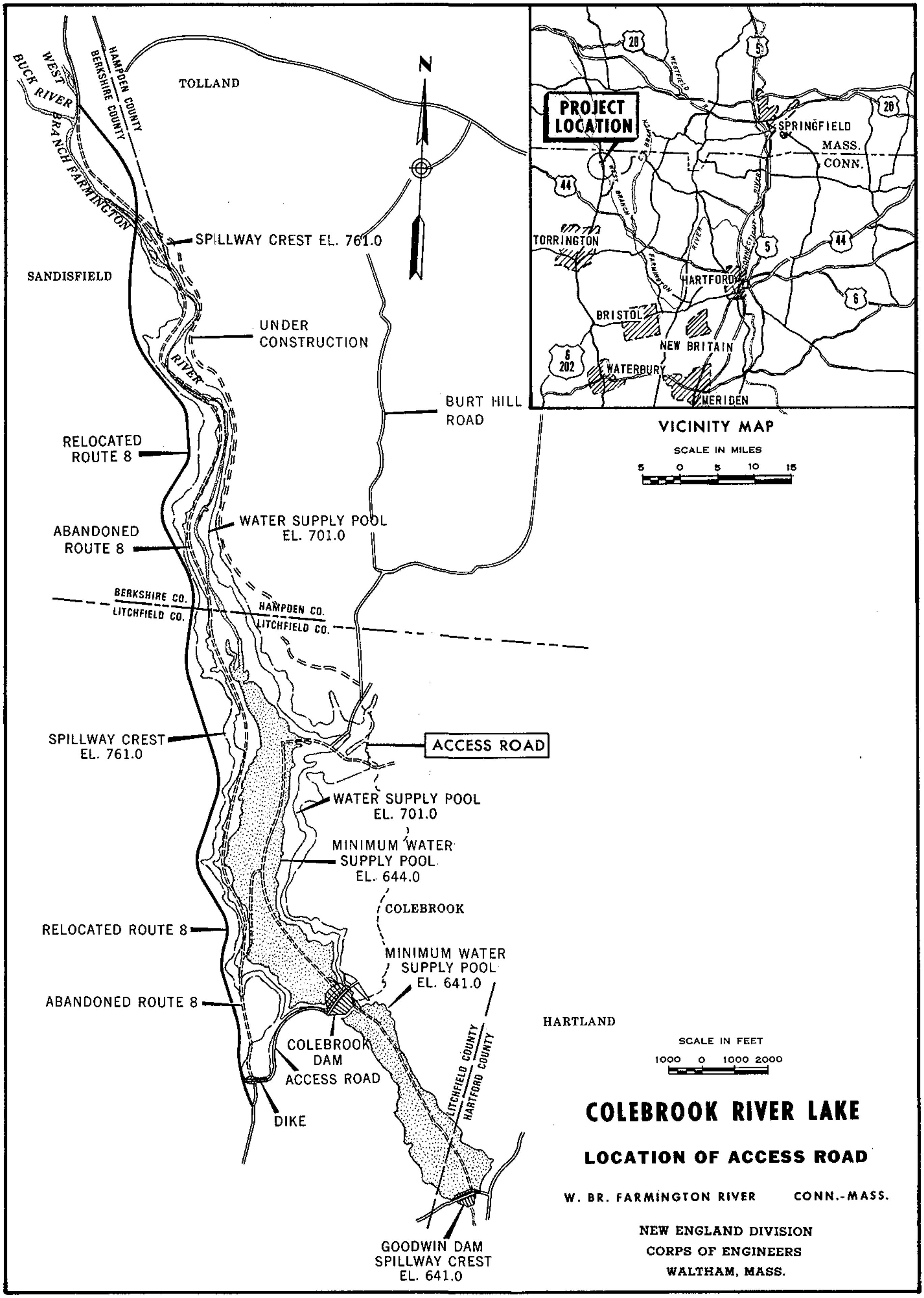
PROFILE
NOT TO SCALE

COLEBROOK RIVER LAKE
HYDROPOWER STUDIES

PROFILE-HYDROPOWER PROPOSAL

(ALTERNATIVE 2)

PLATE 14


TOLLAND
SANDISFIELD
N
WEST BRANCH FARMINGTON RIVER
BUCK RIVER
HAMPDEN COUNTY
BERKSHIRE COUNTY
SPILLWAY CREST EL. 761.0
UNDER CONSTRUCTION
BURT HILL ROAD
RELOCATED ROUTE 8
ABANDONED ROUTE 8
WATER SUPPLY POOL EL. 701.0
BERKSHIRE CO.
LITCHFIELD CO.
HAMPDEN CO.
LITCHFIELD CO.
SPILLWAY CREST EL. 761.0
ACCESS ROAD
WATER SUPPLY POOL EL. 701.0
MINIMUM WATER SUPPLY POOL EL. 644.0
COLEBROOK
RELOCATED ROUTE 8
MINIMUM WATER SUPPLY POOL EL. 641.0
ABANDONED ROUTE 8
COLEBROOK DAM
ACCESS ROAD
DIKE
LITCHFIELD COUNTY
HARTFORD COUNTY
HARTLAND
GOODWIN DAM SPILLWAY CREST EL. 641.0
PROJECT LOCATION
20
5
20
SPRINGFIELD
MASS.
CONN.
44
TORRINGTON
44
5
HARTFORD
6
BRISTOL
NEW BRITAIN
6
202
WATERBURY
MERIDEN
VICINITY MAP
SCALE IN MILES
5 0 5 10 15
SCALE IN FEET
1000 0 1000 2000
COLEBROOK RIVER LAKE
LOCATION OF ACCESS ROAD
W. BR. FARMINGTON RIVER CONN.-MASS.
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

emergency back-up gate. A monorail hoist and stop-gate are provided for emergency closure in case both the service and emergency back-up gates malfunction.

This structure is located on the upstream side of the dam, adjacent to and westerly of the spillway approach channel. Its location relative to the outlet conduit appears on "As-Built" Plate 3. From the invert or sill elevation of 575 feet NGVD at the gate chamber, the total height of the structure to the rooftop approximates 245 feet.

Exclusive of possible minor alteration involving the trash bars, the intake structure is considered acceptable for hydroelectric additions. Mechanically cleaned trash racks were investigated and determined to be too costly to adopt, and rather impractical due to severe winter climate and existing intake configuration. The water supply and flood control reservoir has been completely cleared up to elevation 718 feet NGVD, and will be cleared further to the same extent and manner to accommodate the requirements of each respective alternative. As debris or large objects have posed no problems to date nor are any envisioned, it was assumed that the existing vertical trash bars would adequately and effectively serve the project purpose. In conjunction with the current ongoing maintenance program, securing the services of a diver to periodically inspect the trash bars and affect any remedial clearing action would be far more cost effective.

COFFERDAM

As the water surface (elevation 641 feet NGVD) of the West Branch Reservoir submerges the outlet works of the Colebrook River Lake by approximately 69 feet, construction of the powerhouse and alteration of the existing conduit for penstock adaptation to be performed in the dry could be a costly procedure, particularly if noninterruptible downstream flow releases are to be maintained. However, by appropriately utilizing the West Branch Reservoir, the construction program could be greatly simplified and made cost effective; and still the required flow releases could be adequately maintained.

Several methods were evaluated and their costs are about equal. One approach would be to store a sufficient amount of water in the West Branch Reservoir to supply downstream needs for approximately 7 to 10 days. This would permit construction to take place within the cofferdam area with a minimum amount of interference. Prior to actually constructing the cofferdam, corrugated metal diversion conduits would be prepared. The cofferdam would then be constructed by first lowering the West Branch Reservoir to elevation 570 feet NGVD, where the downstream invert of the Colebrook River Lake would be exposed. At that level, approximately 3 to 5 days of storage (500 acre-feet) would still be available at the West Branch Reservoir, which would provide sufficient time to install a prefabricated diversion pipe, as well as construct the earthen cofferdam embankment up to elevation 580 feet NGVD. The diversion conduit would include a sluice gate element at the cofferdam downstream side. Once the cofferdam is constructed, storage at the West Branch Reservoir would be allowed to build up to a 7 to 10 day storage (approximately 1,000 acre-feet). This approach would provide the contractor a great deal of flexibility in the construction of the power plant, alteration of outlet conduit for penstock adaptation, and other associated features.

A second approach would be to draw the West Branch Reservoir down to elevation 570 feet NGVD, which provides for 3 to 5 day release storage, and exposes the downstream invert of the Colebrook River Lake outlet works. The contractor would then proceed to install prefabricated steel units of the permanent penstock, bifurcation, casing and other ancillary work, utilizing the 3 to 5 day intervals for construction purposes. Once the prefabricated units are installed, he can use them to meet downstream release demands. The releases would be continuous, and the West Branch Reservoir could be maintained at its low level. At its low level, the area adjacent to the outlet and powerhouse sites would be either exposed or have shallow water over it. The area could then be easily developed for the contractor's work area.

It should be realized that the evaluation of these two methods was performed simply to derive a realistic cost. Other viable means of performing this phase of the construction could most likely be developed and should not be precluded at this time. In subsequent detailed investigations, other means for reducing the cost in accordance with practical application will be addressed.

PENSTOCK

The existing 10-foot circular conduit tunnel of reinforced concrete construction measures approximately 774 feet in length from the vertical slide gates at the intake structure to its terminus at the downstream outlet structure. The purpose is to discharge flood control and water supply flows and low flow requirements for downstream riparian owners including the fishery resources.

The conduit was initially designed for hydrostatic pressure. The design contemplated that flows for water supply would be discharged from Colebrook River Lake into the West Branch Reservoir prior to its diversion into Barkhamsted Reservoir via a proposed tunnel. In all probability, that design would be adequate to satisfy the addition of hydropower. If so, modification of the conduit would be unnecessary. However, it was assumed that a steel liner some 800 feet in length should be included at this time pending further advanced study.

An effective and economical method for strengthening the conduit entailed a welded steel liner inserted inside the existing conduit. It would consist of prefabricated sections welded together when an unwatered condition exists. The annular area between the liner and existing conduit would then be grouted with concrete.

POWERHOUSE

General

The existing outlet structure consisting of concrete retaining walls and a tailrace apron would be demolished and replaced with a powerhouse structure. At that point, the penstock would be bifurcated as shown on Plate 16. One section would direct flows into the turbine via the spiral case, the other would serve as the flood control bypass. Both sections, each equipped with gates, would control flows either in one or both directions as warranted by operating conditions.

As the powerhouse structure would be submerged during flood storage levels of the West Branch Reservoir, to obtain the most economical reinforced concrete structure, a circular form was selected and would apply for elevations above 590 feet NGVD. Below that level the substructure would be rectangular in shape. Also, due to the partial submergence of the building, an indoor power facility as opposed to outdoor or semi-indoor was selected.

A virtually continuous bedrock outcrop with thin, patch overburden cover exists in this area. Boring and testing data presented in the Design Memoranda for Colebrook River Lake Dam indicate that bedrock is a competent gneiss and granite sequence which would provide adequate support for the anticipated structure.

Mechanical Equipment

The major electromechanical components of the power plant are the intake valve, turbine, generator, draft tube, draft tube gates, flood bypass gate, control and protection equipment. Other miscellaneous plant equipment required for normal operation and maintenance of the power plant includes: bridge crane, station light and power systems, fire protection system, heating and ventilating equipment, potable water system and sanitary facilities.

Turbines - The utilization of a single, vertical, propeller Kaplan runner turbine equipped with wicket gates for controlling flow into the turbine was considered most suitable to the site, and would apply for Alternatives 1, 2 and 4. For Alternatives 3 and 5, reversible pump turbines would be required. A single unit versus multiple units was considered applicable because the downstream West Branch Reservoir would serve as a reregulating reservoir, avoiding the need to be able to generate under a wide range of flows and permitting intermittent single unit operation at near optimum discharge.

The tailwater elevation can fluctuate 31 feet, therefore, an adjustable blade (Kaplan) unit was chosen due to its higher operating efficiency under a varying range, 60 to 140 percent, of design head. The Kaplan unit equipped with wicket gates can also operate quite efficiently under varying discharges, 40 to 105 percent, of design capacity.

For Alternative 2 the turbine would have a throat diameter of 4.6 feet. Assuming a combined turbine and generator efficiency of 80 percent, the output of the generator would be approximately 3.5 Mw.

The selection of turbine size was based on the capacity of a steel-lined outlet works used as a penstock, the monthly flow characteristics at Colebrook River Lake and the head differential between Colebrook River Lake and West Branch Reservoir. The selected capacity was adequate to harness practically all hydropower energy potential of the site at a reasonable average annual plant factor. Further optimization of selected turbine style or configuration and installed capacity may result with more detailed design studies.

Miscellaneous Mechanical Equipment - For the normal operation and maintenance of the power plant, other major mechanical equipment is required and their purpose is as follows:

1. The shutoff control of intake water into the spiral case would be by a hydraulically operated butterfly valve supplied with the turbine package.

2. Flow of water through the turbine would be controlled by means of wicket gates mounted in the water passage at the turbine.

3. Control of water flow in the flood control bypass would be accomplished by a hydraulically operated slide gate.

4. A bridge crane would be provided for placement or removal of the generator and turbine.

5. Standard ceiling-type exhaust fans would be provided for powerhouse cooling. As the generators are air-cooled, the fans would be sized to maintain temperature limits using outdoor air only.

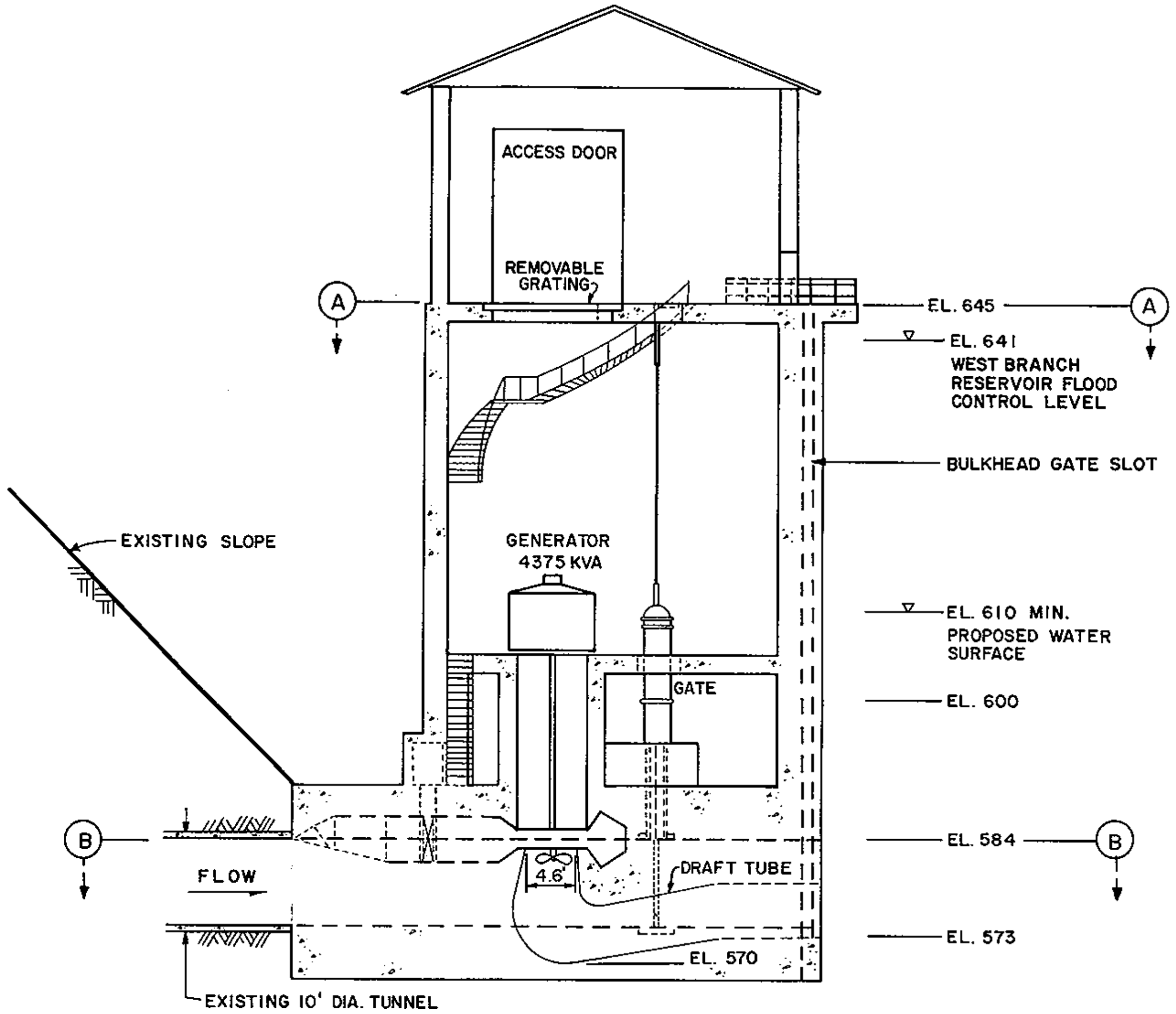
6. Draft tube gates would be provided to permit dewatering of the turbine for periodic inspection and maintenance. Unit dewatering would be accomplished with a submersible pump.

7. Stoplogs on the downstream face of the powerhouse would also be included for emergency purposes.

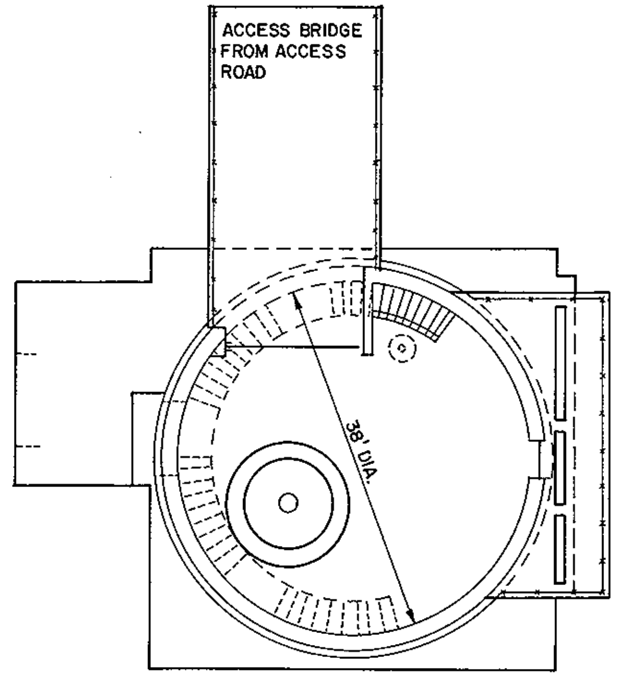
Other miscellaneous mechanical equipment would be required, but for this study, their costs are included either in the miscellaneous power plant equipment or in the contingency items.

Electrical Equipment

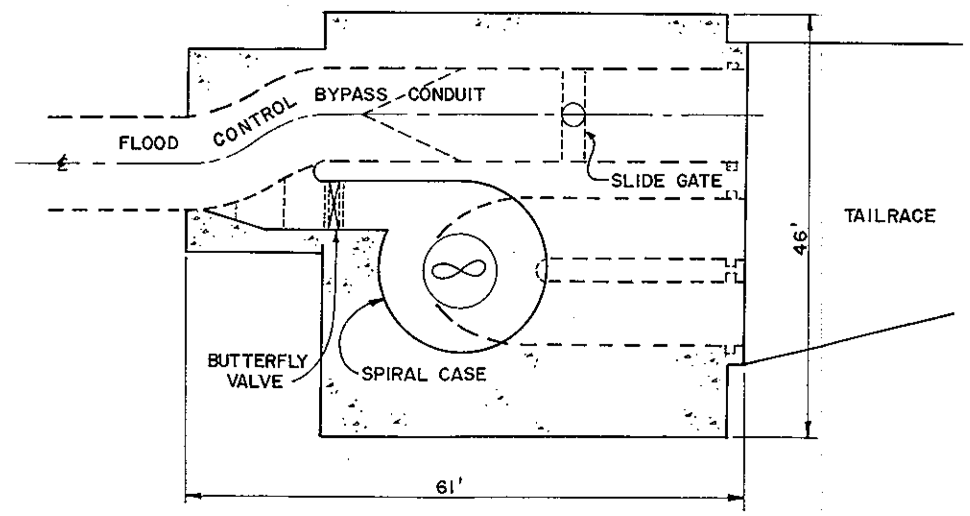
General - Generators are either synchronous or induction types. The synchronous unit is equipped for self-excitation and synchronization before going onto the grid; whereas, the induction generator relies on power from the grid for excitation. Induction generators are somewhat cheaper in cost and more applicable to small installations; however, utility companies are reluctant to having numerous small units in the system capable of draining power from



POWERHOUSE ELEVATION
SCALE: 1" = 10'



SECTION A-A
SCALE: 1" = 10'



SECTION B-B
SCALE: 1" = 10'

GRAPHIC SCALE
1" = 10' 10' 0 10' 20'

COLEBROOK RIVER LAKE
HYDROPOWER STUDIES
POWERHOUSE ELEVATION & SECTIONS
WEST BRANCH FARMINGTON RIVER CONN. & MASS.
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

the grid for excitation. Therefore, for this study, synchronous generators were assumed for all alternatives. Generators would have rated capacities equal to or greater than the rated turbine capacity and also be capable of operating continuously at a 15 percent overload.

Generator and Breaker - The synchronous generator for Alternative 2 would be rated 4375 kilovolt amperes (Kva), 0.8 power factor (PF), 3-phase, 60 hertz (Hz), 5.0 kilovolts (Kv), 900 revolutions per minute (rpm). A drip-proof guarded enclosure would be provided for the generator. The generator would have an 80° Celsius (C) rise Class B insulation system. It would also have full runaway speed capability thereby eliminating the need for a disconnect clutch. The generator breaker would be a metal-clad drawout type rated 250 megavolt amperes (Mva) (nominal), 7.5 Kv, 1200 amperes (amp) continuous. Breakers would be in metal-clad switchgear together with generator surge protection, instrument transformers, instruments and relays.

Excitation System - The excitation system for the unit would be of the bus-fed, power potential source, static type; excitation power being derived from the generator terminals. During starting, the generator field would be automatically flashed (permitting generator voltage buildup) from a rectified A-C station service source.

Unit Control and Protective Equipment - A complete complement of generator protective relays (differential, overvoltage, overcurrent, etc.) startup and shutdown controls and other unit control relays would be provided in the metal-clad switchgear lineup containing the generator circuit breaker. Synchronizing would be accomplished by speed switches. The generator breaker would close at 95 percent speed with the static excitation system being energized at 98 percent speed. The generator would be provided with connected amortisseur windings to facilitate pull-in with the system. The packaged unit would have electrical and mechanical protective devices, as indicated on the main one line diagram, Plate 17.

Station Service - There would be two separate sources of station service power. One source would be either from generator voltage or transmission line; the other would be tapped from the common local 4.8 Kv distribution line. Station service switchgear would be arranged to provide full service from either source. Also, the former above source would supply station service from the single unit when generation into the utility system is shut down. Station service switchgear (4800 volts) would be included in generator circuit breaker switchgear lineup. Station service power distribution would be at 480 volts, 3-phase and 120/240 volts single phase.

Connection to Load-Transmission Lines - Normally, connection to a power grid system is determined by an appropriate marketing agency under DOE. However, as the cost of transmission facilities could drastically affect the economic justification of a project, it was considered necessary to investigate the cost associated with a possible tie into some grid system. Upon consultation with the public utilities, a 3-phase 4.8 Kv overhead transmission line tied directly to the local utility substation (Connecticut Light and Power Company) at Robertsville, Connecticut was selected. That substation is approximately 2-1/2 miles from the powerhouse site. The power can normally be used on their local 4.8 Kv system, and any excess used on their transmission network. With this transmission system, there would be no need of a substation at the Colebrook River Lake powerhouse.

It should be emphasized that this tie into the grid system at Robertsville should not preclude the possibility of connecting to other points, as the transmission cost was developed solely to demonstrate economic viability of the project proposal. Prior to final design, an investigation in conjunction with the appropriate marketing agency to be established at some future time will be made into using a 68 Kv transmission line versus the 4.8 Kv line.

RECREATIONAL FACILITIES - MITIGATING MEASURES

Mitigating measures involving recreational facilities for Alternatives 2 and 3 would include raising the parking area of Colebrook River Lake Boat Launching Area by 4-feet and extending the boat ramp. For Alternatives 4 and 5 all facilities would require total relocation. Alternative 1 requires no change.

RESERVOIR CLEARING

Colebrook River Lake is currently cleared to elevation 718 feet NGVD. However, by increasing the normal full pool for Alternatives, 2, 3, 4 and 5 to required elevations, additional acreages of clearing would be required. Furthermore, additional clearing of acreage associated with the contractor's work area, the powerhouse and access road construction is considered minor and has been omitted from evaluation at this time.

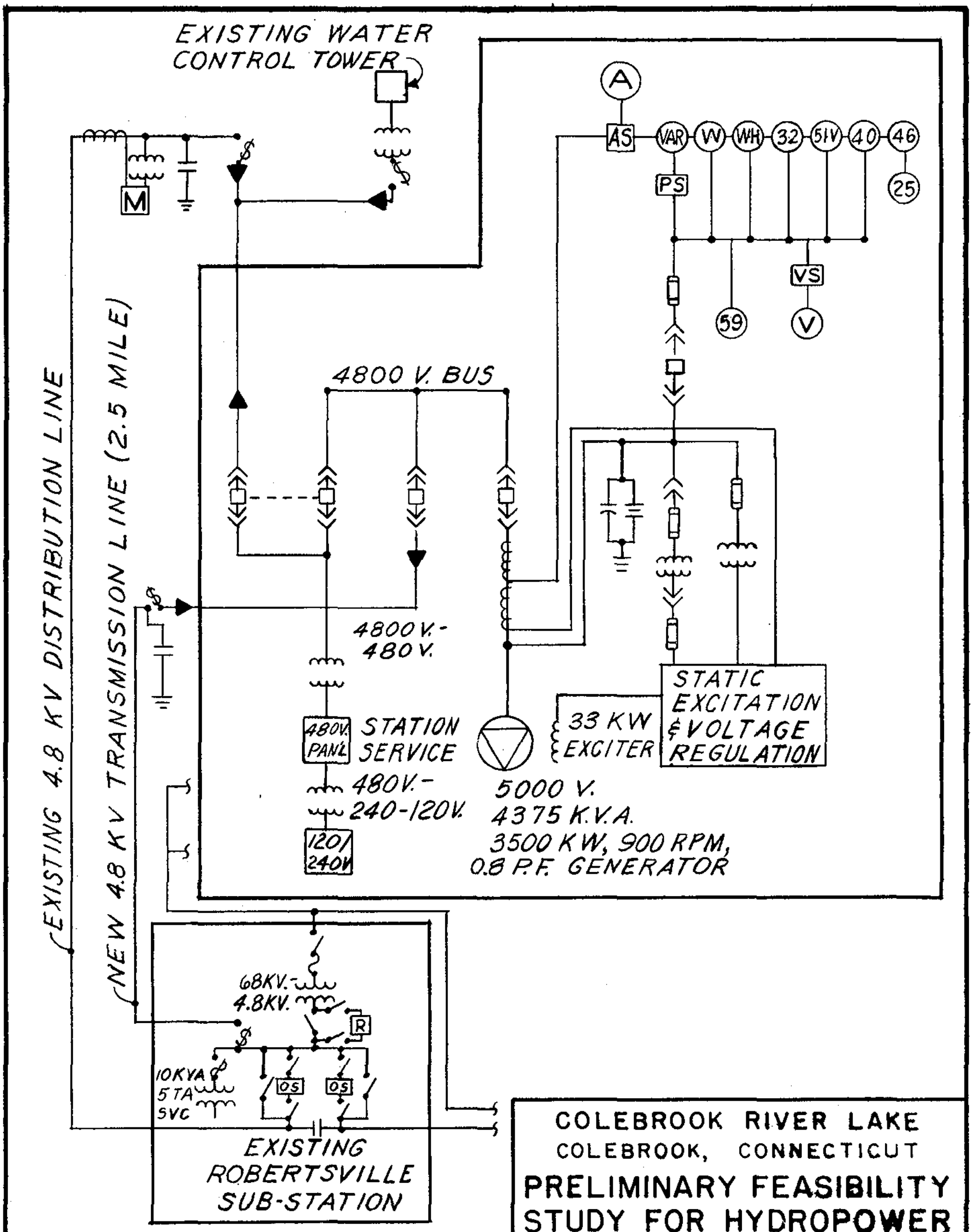
LAND AND DAMAGES

For Alternatives 1, 2 and 3 no additional real estate acquisition would be required. Total land acreage affected by Alternatives 4 and 5 would consist of 350 acres, of which 160 acres would be purchased in fee within the upper extremities of the reservoir in Massachusetts. The remaining 190 acres would be acquired as flowage easements, of which 60 acres are in Connecticut, and the remaining 130 acres in Massachusetts.

Improvements or buildings to be purchased outright, and all located in Sandisfield, Massachusetts, would involve nine residential dwellings and one commercial unit.

Other items included in the real estate acquisition would be the severance damage, acquisition and relocation assistance costs.

Real estate acquisition costs were evaluated by use of the market data or sales comparison approach. This approach involves a comparison between the subject properties and recent sales transactions of properties located in the vicinity of the project area. Therefore, search of records, as well as interviews with local officials, real estate brokers and appraisers, and other knowledgeable persons for obtaining and substantiating the market data and value estimates were conducted. The resultant total acquisition estimates appearing in Table



COLEBROOK RIVER LAKE
COLEBROOK, CONNECTICUT

PRELIMINARY FEASIBILITY STUDY FOR HYDROPOWER

ELECTRICAL

MAIN ONE LINE DIAGRAM

15 represent an unbiased judgment of the present fair market value of affected properties within the project area.

PROJECT COSTS AND INVESTMENT

Total project investment costs were developed in accordance with established engineering standards and reflect January 1981 price levels. Required modification or alteration of project features as analyzed appear in Table 15 for all five alternatives. Those costs include a contingency allowance for unforeseen project conditions or uncontrollable factors. From previous experience and knowledge of similar studies, the application of a 20 percent contingency factor is considered to be adequate.

In addition, an overhead rate of 10 to 11.1 percent, varying upon project cost, and derived from comparative project studies undertaken within this office applies for engineering and design. For supervision and administration the percentage value is 8.5 to 8.6 percent of varying project cost, and was extracted from a curve developed from cost performance data in the administration and supervision of civil construction work at NED. No interest during construction was considered as the construction period would be less than two years. Finally, the cost items, as identified in column 1, Table 15 have been grouped to conform, as closely as possible, to the FERC's cost accounting system.

TABLE 15

TOTAL PROJECT COSTS AND INVESTMENT

COLEBROOK RIVER LAKE

ITEMS	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Structures & Improvements	$1,085,000	$1,110,000	$1,110,000	$1,110,000	$ 1,110,000
Reservoirs, Dams & Waterways	1,035,000	935,000	935,000	2,635,000	2,635,000
Turbine & Generators	800,000	800,000	1,380,000	800,000	1,380,000
Station Electrical Equipment	275,000	330,000	330,000	360,000	360,000
Misc. Power Plant Equipment	80,000	90,000	90,000	100,000	100,000
Transmission Lines	400,000	440,000	440,000	470,000	470,000
Mitigation Measures	0	200,000	200,000	270,000	270,000
Reservoir Clearing	0	80,000	80,000	220,000	220,000
Construction Cost - SUBTOTAL	$3,675,000	$3,985,000	$4,565,000	$5,965,000	$6,545,000
Contingencies 20%	735,000	797,000	913,000	1,193,000	1,309,000
SUBTOTAL	$4,410,000	$4,782,000	$5,478,000	$7,158,000	$ 7,854,000
Engineering and Design	490,000	526,000	592,000	744,000	785,000
Supervision and Administration	379,000	409,000	468,000	608,000	668,000
SUBTOTAL	$5,279,000	$5,717,000	$6,538,000	$8,510,000	$ 9,307,000
Land and Damages	0	0	0	770,000	770,000
TOTAL PROJECT FIRST COSTS	$5,279,000	$5,717,000	$6,538,000	$9,280,000	$10,077,000
(ROUNDED)	$5,280,000	$5,720,000	$6,540,000	$9,280,000	$10,080,000
INTEREST DURING CONSTRUCTION	0	0	0	0	0
TOTAL INVESTMENT COSTS	$5,280,000	$5,720,000	$6,540,000	$9,280,000	$10,080,000

Study Schedule

GENERAL

The planning schedule would be contingent upon adequate funds. It would commence in October 1981 with the final report, consisting of a main report, appendices, and an EIS, if one is necessary, completed by 1 April 1983. The feasibility report in draft form would be available for review by the Office of the Chief of Engineers (OCE) on 1 October 1982. With appropriate revisions the report would than be released in January 1983 for the public and agencies review, and published in the Federal Register. In this time frame, a final public meeting would be held. By 1 March 1983, final revisions and comments as needed would be initiated and completed by 1 April 1983, at which time Stage 3 planning process would be terminated with the submission of the final report subsequently forwarded to Congress with appropriate recommendations.

A bar graph illulstrating the sequence of planning events is attached as Figure 4. A brief and general descriptive coverage of each major study element involving Stage 3 planning process is included in the following paragraphs.

PUBLIC INVOLVEMENT

Significant in the direction of the study effort will be a public involvement program for channeling study information to all interested parties, and funneling their responses to this agency which is responsible for conducting the study. The objectives and strategy of the public participation program are further discussed in Section VIII of the text.

It is envisioned that two individual public meetings would adequately and objectively satisfy the needs of the public. The first would be scheduled possibly the third week of September 1981, and would be held in Connecticut, possibly Winsted. The second public meeting would be scheduled during the review period of the final Stage 3 report, occurring in fall 1982. Additional workshop meetings with local and other interested groups would be held during the study period as required.

An immediate task would be the preparation of a mailing list with subsequent periodic updating as required. To assist in informing the public, display material and information "handouts" for use in meetings and workshops would be prepared and revised as the study progresses. Another task of equal importance would be preparation of letter replies to inquiries, and other informative data for public dissemination.

The Public Involvement Program would be generally considered an on-off assignment requiring periodic involvement, and is so reflected in the bar graph scheduling of Figure 4.

AGENCIES COORDINATION

Each phase of the final feasibility study will be fully coordinated with other Federal, State, regional and local agencies having a vested interest in the planning or development of water resources within the study area. Agencies that would logically participate and provide input, and some of their delegated responsibilities are as follows:

Federal

Under the provision of Section 5 of the Flood Control Act of 1944 (P.L. 534, 78th Congress) and other acts, power developed at multiple-use reservoirs under the jurisdiction of the Corps of Engineers is turned over to the Secretary of Energy for marketing. The Department of Energy (DOE) agency that would market the power from Colebrook River Lake would be established at some future time. The rates set by the marketing agency would be approved by the Federal Energy Regulatory Commission (FERC), which would be responsible for all the elements involved in determining power values. Therefore, the Corps would coordinate with FERC in evaluating power benefits on the basis of unit power values to be developed by FERC and would also coordinate with the appropriate marketing agency for power marketability.

Under the Fish and Wildlife Coordination Act of 1958 (P.L. 85-264), as amended, fish and wildlife conservation has already received consideration with the project features of the existing Colebrook River Lake. However, possible effects on the fish and wildlife resources due to addition of hydropower as a project purpose and opportunities for mitigation would need to be examined under the Act. Therefore, this study would be appropriately coordinated with the U.S. Fish and Wildlife Service, and also with the agencies administering the fish and wildlife resources of the State of Connecticut and the Commonwealth of Massachusetts.

There are various other Federal agencies that would have major inputs to this study, and upon which coordination would be a prerequisite. For instance, the Environmental Protection Agency (EPA) would be involved with environmental considerations particularly as they pertain to water quality, and possibly other concerns. The Advisory Council on Historic Preservation would wish to evaluate the considerations of cultural resources. As the study progresses, other Federal agencies could possibly become more actively involved, perhaps under other statutes, such as the Federal Water Project Recreation Act of 1965 (P.L. 89-72) as amended, for recreational consideration of project use.

State

Environmental agencies of both states, namely the Commonwealth of Massachusetts, Division of Fisheries and Wildlife, and the Connecticut Department of Environmental Protection (DEP), have been apprised of our study. Per letters attached as Appendix A and B, respectively, both agencies have commented on the five alternatives under consideration. Ongoing coordination

STAGE 3 PLANNING SCHEDULE
Colebrook River Lake Project

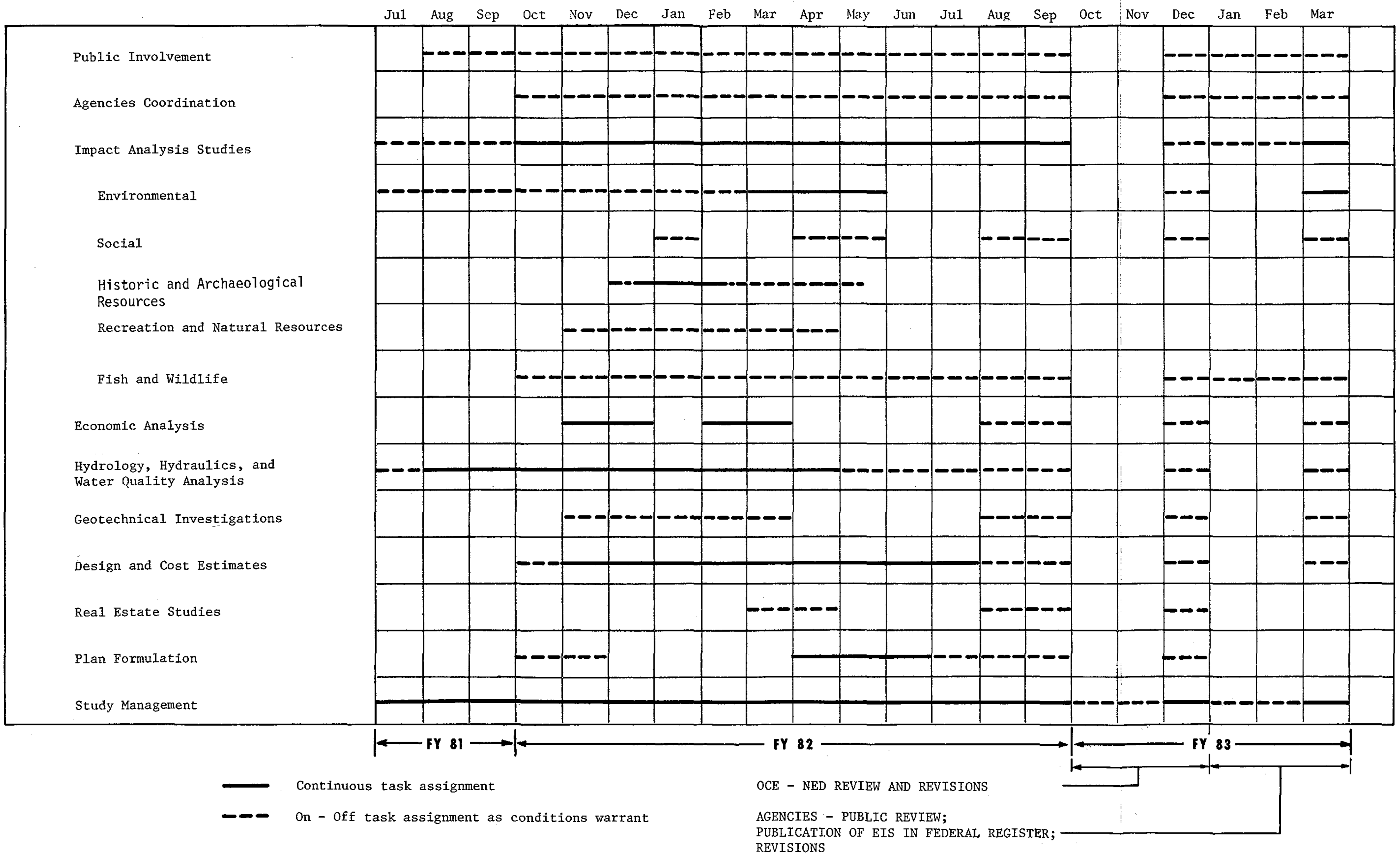


FIGURE 4

and cooperation with those agencies would continue and be expanded to include other State agencies having a vested interest in the project.

Regional

Coordination efforts would also be extended to include regional agencies and organization such as the New England Regional Commission (NERCOM), the New England River Basins Commission (NERBC), the Connecticut River Flood Control Compact Commission, The Farmington River Watershed Association and others. These agencies have either shown a degree of interest in the development of nonfossil and renewable energy resources, or have the capability and willingness to become actively involved in the planning activities, and could be effectual in seeing that an acceptable plan is readily implemented. Therefore, coordinated efforts and cooperation with those regional agencies in seeking their advice, assistance and support would be pursued.

Local

The planning activities would also be coordinated with local government and local regional planning agencies and the Hartford MDC. The latter, a municipal corporation created by the Connecticut State Legislature, has as one of its primary functions the task of supplying the water needs for the city of Hartford and numerous nearby towns. As future water supply needs would be partly met from storage at Colebrook River Lake where the Hartford MDC has cost shared in the construction of that project for an equivalent 10 billion gallons of water supply storage, the Hartford MDC has a prevailing interest in the project. Furthermore, as reserved water supply, storage and flow releases through the existing conduit would be utilized for hydropower, resulting in cost sharing of joint use facilities, their interest would be intensified. Therefore, ongoing cooperation and coordination would be maintained and expanded to actively solicit their opinions and perceptions of problems, issues, concerns, and objectives; and their preferences regarding resource use and alternative development or management strategies.

IMPACT ANALYSIS STUDIES

The major features of this work element would consist of the overall study management in the preparation of the EIS. It would include scoping, and coordination and would embrace the following tasks:

Environmental

The environmental studies would include the development of the EIS. These studies would produce a draft EIS to be filed for agency and public review and published in the Federal Register by the second quarter of Fiscal Year 1983. Following the National Environmental Policy Act (NEPA) review, the final EIS would be prepared and forwarded to OCE for appropriate action.

Social

The major task for social input would involve the preparation of the social well-being portion of the social and cultural resources appendix. Any new data provided on project alternatives would also receive consideration for updating and refining current study input. A more detailed assessment of project alternatives would also be an anticipated activity.

Historic and Archaeological Resources

Depending upon the alternative, associated cultural resource activities could range from a simple coordination endeavor with relevant State and Federal agencies to a cultural resource reconnaissance effort.

Recreation and Natural Resources

This study element would include a background analysis of recreation resources, supply, demand and needs in the project area, and an assessment of the recreation options for each of the alternative plans under consideration. Recommendations for optimum recreation development, costs, benefits, management and cost sharing would be discussed.

Fish and Wildlife

In compliance with the Fish and Wildlife Coordination Act of 1958 and Section 7 of the Endangered Species Act of 1973, the Fish and Wildlife Service of the Department of the Interior, under contract with this office, would provide consultation and recommendation in matters relating to fish and wildlife resources, including any effects on threatened and endangered species resulting from the project proposal.

ECONOMIC ANALYSIS

Required tasks relating to this element would be as follows: (1) coordinate with FERC to determine whether or not a value for dependable capacity for Alternatives 3 and 5 (reversible units) would be allowed; (2) obtain from FERC current dollar values for capacity (if allowable) and energy values to compute power benefits; (3) compute employment benefits based on the local labor component of construction cost; (4) compute and discuss benefit-to-cost (B/C) ratios and net benefits for each alternative; (5) perform relative price shift analysis and sensitivity analysis; (6) perform analyses to maximize net benefits for plans with positive B/C ratios; (7) discuss power marketing; (8) discuss and perform allocation of costs and charges among users for storage and joint facility use; (9) perform incremental analysis (if required); (10) write and display summary of economic analysis with rationale for the selected plan.

HYDROLOGY, HYDRAULICS AND WATER QUALITY ANALYSIS

It is envisioned that hydrological and hydraulic engineering studies required for Stage 3 would involve: sequential project operation and loading studies; resulting pool fluctuation and flow analyses; Colebrook River Lake operation as part of the Farmington River reservoir system; dependable and intermittent capacity assessment at Colebrook River Lake; and miscellaneous other tasks required in the formulation process of the hydroelectric power potential.

Water quality engineering studies would include the collection of baseline water quality data for the characterization of existing conditions, and for the calibration of a mathematical reservoir temperature and dissolved oxygen model. Water quality conditions in both reservoirs and downstream as influenced by the modified operating schemes would be predicted. Information concerning predictable conditions and impacts would serve as input to the environmental impact studies.

GEOTECHNICAL INVESTIGATIONS

Major geotechnical efforts for Stage 3 report would primarily be geared to providing professional services and support to the engineering design units in matters relating to geotechnical features. Other principal functions for report input would involve: research and assimilation of stability and foundation data; additional field reconnaissance of proposed project features; updating and revising "as-built" drawings; and preparing new drawings as required.

DESIGN AND COST ESTIMATES

The objective of this technical element would be to refine and to detail the design features, and to cost estimate the proposals involving both the National Economic Development (NED) and Environmental Quality (EQ) plans.

Design efforts would include input from the structural, mechanical, electrical and civil engineering fields of expertise with guidance provided by geotechnical engineers and by hydrologists. Major design features to be investigated in greater detail would include the generators, mechanical and electrical equipment, various closure gates, trash rack, and the powerhouse structure.

In consultation with various manufacturing firms, and other Corps offices if the need should arise, the optimum type of generating unit and appurtenant components conducive to project efficiency would be selected and detailed accordingly. Some further design efforts would also be spent on selecting the type, size and location of the various control structures and gates. Structural analysis of the powerhouse would include structural stability as well as sizing of some of the critical structural elements of the power plant. An analysis of the penstock would also be undertaken to ascertain the need for a lining as well as to provide for a more accurate cost. As the access road has been already investigated rather extensively, there would be no need for additional extensive refinement.

The project proposals involving the NED and EQ plans would be detailed accordingly and costed. If and wherever applicable, cost estimates would include an update or adjustment of current costs developed as part of this preliminary feasibility report.

REAL ESTATE STUDIES

The task examining the fair market value of the real estate interests and allied real estate costs for the acquisition of additional lands and improvements required for hydropower modification of the Colebrook River Lake Project has been substantially completed. Further work input would consist of preparing a revised cost update to reflect current price levels, and assimilating supporting data for replies to public inquiries.

PLAN FORMULATION

The objectives of the plan formulation process would be to develop within the framework of the Principles and Standards (P&S) both an NED and EQ plan that would sustain hydroelectric power potential as an integral part of the project purpose while enhancing, preserving and maintaining the water and related land resources of the project area.

Currently five alternatives are under consideration with one alternative chosen as the "most likely" selected plan. As that selection was based solely on the cost (mills/Kwh) at which power could be sold and on limited environmental considerations, only three alternatives (1, 2 and 4) were part of the initial formulation process. However, Alternatives 3 and 5 involving reversible units were held in abeyance pending a final determination of pumping costs, and whether or not power capacity values would be allowed. Subsequent studies would undertake the task of substantiating those preliminary findings, and of developing plans that would contribute to NED and EQ objectives. Those objectives would be readily achieved primarily by a sequence of events as described in the following paragraphs.

While the potential power values (energy and capacity) that could be credited to the project are being determined by DOE, the design features of Alternative 2 would be examined more closely, refined wherever needed, and the related costs updated and annualized. The basic data as developed and verified for Alternative 2 would be used on a comparative basis to adjust the features of Alternatives 1 and 4, with an update and annualization of costs. As the power values become available an evaluation as to whether Alternatives 3 and 5 warrant further investigation would be made on the basis of capacity and associated pumping cost values. If credit values are disallowed by DOE, Alternatives 3 and 5 would cease to be considered; otherwise their evaluation including refinement of costs and annualization would be warranted. At this point, it would be assumed that all costs and benefits resulting from the evaluation procedure would be relative. In addition, the impact analysis studies for all five alternatives would be concurrently pursued.

The next planning phase would be the plan formulation process involving all alternatives that could be justifiably retained. Those alternatives would be initially rated according to economic justification including incremental cost analyses. The development of a plan or plans that contributes to the NED and EQ objectives would be generated through an iteration process involving a display of all associated impacts and economic justification. The ensuing recommended NED and EQ plan(s) would then be finalized. The finalized process would involve a final refinement of project features, if the need exists, latest update of cost and annualization figures, and preparation of plans of sufficient detail to satisfy the requirements of a feasibility report.

STUDY MANAGEMENT

The overall management responsibility for preparation of the feasibility report would continue to be contained within the Hydroelectric Energy Studies Branch (HESB) of the Planning Division of NED. Assistance and guidance would also be provided by a study team composed of a group of experts well versed in various study disciplines within NED.

The study management would be accountable for the accomplishment of all project tasks required for report preparation. Major management functions would consist of: (1) establishing schedules of support services, participating in the formulation of project plans and any subsequent modifications, and monitoring the contents and delivery of data; (2) establishing public involvement programs with the public, Federal, regional, State and local agencies; and (3) programming, allocating and accounting of funds required for study completion.

Economic Analysis

GENERAL

This section of the report contains the financial feasibility analysis of the five proposed hydroelectric alternative plans at Colebrook River Lake. The analysis procedures involve cost sharing of the proposed hydropower addition to the project purposes. A simplistic relative price shift analysis has been applied to emphasize the increasing cost of alternative fuel which would be displaced by hydropower. The section also includes a discussion of the marketability of hydropower produced by a Federal installation in order to display the value of energy produced by the various alternatives.

COSTS AND CHARGES

Table 16 shows the annualization of project costs for all alternative plans. The total project costs and investment for modifying or altering existing Colebrook River Lake facilities for hydropower adaptation appears in greater detail in Table 15 of Section V.

The annualization of project costs is based on a capital recovery factor reflecting an interest rate of 7-3/8 percent with amortization over a 50-year life of the project. Included in the annual charges are allowances for operation and maintenance, and major replacements.

Since the analysis attempts to ascertain preliminary economic justification via the benefit-cost ratio, the current Federal interest rate of 7-3/8 percent was employed. At a later stage of the study a financial repayment analysis will be performed by the marketing agency. This will involve repayment of construction costs allocable to hydropower purposes, through marketed power, based on an interest rate determined by the Department of the Treasury for the Department of Energy (current rate: 8/5 percent).

As operation of the Colebrook River Lake hydropower project would result in increased regulation procedures at Goodwin Dam, an annual contingency cost above current operating expenditures would be required and chargeable to the hydroelectric development proposal. Operating procedures would be vested with the Hartford MDC on a reimbursable basis. An annual cost of $2500, as tentatively submitted by the Hartford MDC and concurred with by this office, appears adequate at this time. In addition, the operation and maintenance for Colebrook River Lake would include costs as shown in Table 16, for staffing (an additional person), materials and supplies, and minor maintenance work.

Major replacement represents an allowance for project items deemed to have a usable life less than that of the project. Major items would include gates and their mechanism, miscellaneous minor turbine and generator parts, and electrical and mechanical equipment associated with hydropower facilities that would require periodic replacement.

TABLE 16

TOTAL PROJECT INVESTMENT COSTS AND ANNUAL CHARGES

COLEBROOK RIVER LAKE

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
TOTAL PROJECT INVESTMENT COSTS	$5,280,000	$5,720,000	$6,540,000	$9,280,000	$10,080,000
ANNUALIZATION					
Interest and Amortization	400,800	434,200	469,500	704,400	765,200
Operation and Maintenance					
(Goodwin)	2,500	2,500	2,500	2,500	2,500
(Colebrook)	30,000	30,000	35,000	30,000	35,000
Major Replacement	2,400	2,500	3,500	5,600	6,700
Pumping Cost			*		*(**)
	$ 435,700	$ 469,200	$ 537,500	$ 742,500	$ 809,400

*Assuming that the net annual energy production would be equal to that of Alternative 2 (**Alternative 4), and that there would be no net gain or loss due to pumping operations, i.e., the difference in the cost of energy for pumping and the value of added generated energy would be sufficient to offset the energy losses in the operation.

COST ALLOCATION

Under existing conditions, a water transfer conduit serving the dual purposes of flood control and water supply is being cost shared by the Federal Government and the Hartford MDC. Under the proposed plans, an additional purpose, hydropower, will be introduced and will share the use of the conduit. Thus, as the study progresses, a new cost sharing arrangement will have to be determined for use of storage and joint use of Government facilities.

BENEFITS

As this is a preliminary feasibility report and the installed capacity of each alternative is relatively small, the resource cost of the most likely alternative will not be used as a measure of the benefit to the hydroplant. The project benefit will ultimately be determined by the amount for which the power can be sold to a public body, a power cooperative or private utility. Due to the variability of costs of energy production and the preliminary nature of this report, an array of benefits was developed based on a range of 40 to 80 mills (4 to 8 cents) per Kwh.

The figure of 40 mills per Kwh is an approximation of the present day value. All benefits were derived by multiplying the annual energy output of the plant by the unit energy value. Table 17, which follows, displays the array of annual benefits, the annual cost and B/C ratios for the alternative plans.

TABLE 17

ANNUAL BENEFITS AND COSTS AND BENEFIT-TO-COST RATIOS

	Mills/Kwh	Energy Benefit ($)	Annual Cost ($)	Benefit/Cost Ratio
	40	324,000		.74
	50	405,000		.93
Alternative 1	60	486,000	435,700	1.12
	70	567,000		1.35
	80	648,000		1.49
	40	544,000		1.16
	50	680,000		1.45
Alternative 2	60	816,000	469,200	1.74
	70	952,000		2.03
	80	1,088,000		2.32
	40	544,000		
	50	680,000		
Alternative 3	60	816,000	537,500	
	70	952,000		
	80	1,088,000		
	40	756,000		1.02
	50	945,000		1.27
Alternative 4	60	1,134,000	742,500	1.53
	70	1,232,000		1.78
	80	1,512,000		2.04
	40	756,000		
	50	945,000		
Alternative 5	60	1,134,000	809,400	
	70	1,323,000		
	80	1,512,000		

Alternatives 3 and 5 may also provide for dependable capacity. At the present level of analysis this potential credit is not quantified.

RELATIVE PRICE SHIFT ANALYSIS

The Manual of Procedures for Evalution of National Economic Development (NED) Benefits and Costs in Water Resource Planning-Level C (Water Resource Council) states that "benefits may vary over the life of a project." One of the chief reasons for this variation (if the most likely alternative to the project is a thermal plant) is real escalation in fuel costs. If it is assumed that the price range of power used in this study is similar to the value of power produced by oil-fired plants, a relative price shift analysis can be undertaken. To ensure efficiency in the use of planning resources for such small scale hydropower projects, this analysis has been undertaken using a very simplistic approach. Despite these simplifications, the relative price shift analysis proves to be a useful tool by emphasizing the increasing cost of fuel that would be displaced by hydropower generation.

The energy price projections employed are those published by the Department of Energy (Federal Register/Vol. 45, No. 16/Jan 23,1980). Fuel prices (distillate, industrial sector) are per million Btu (British thermal unit) in 1980 dollars for DOE Region One (New England). Projections are annual charges calculated in five year increments from 1980 to 1995, and are as follows:

Year	Price Per Million Btu's	Energy Price Escalation Rate (Percent Change Compounded Annually)
1980	6.22	
		1980-1985: 1.32
1985	6.64	
		1985-1990: 1.95
1990	7.32	
		1990-1995: 3.66
1995	8.76	

It was ascertained from various sources that roughly 80 percent of the cost of energy production for a thermal plant is fuel. For purposes of analysis, 80 percent of each power value in the range from 40 mills to 80 mills was increased by the appropriate percentage annually to 1995. After escalation, the fuel portion and nonfuel portion (20 percent) were combined. The value at 1995 was assumed to exist until the 50th year of project life. Escalated energy values for each year of project life were then discounted and annualized over the 50-year period resulting in a levelized energy value applicable annually. The escalated base energy values are displayed as follows:

Base Value	40 Mills	50 Mills	60 Mills	70 Mills	80 Mills
Escalated Value @ 1985	42.2	52.7	63.3	73.8	84.3
Escalated Value @ 1990	45.6	57	68.5	79.9	91.2
Escalated Value @ 1995	53	66.3	79.6	92.9	106
Levelized Energy Value	49.6	62.0	74.5	86.9	99.1

The relative price shift analysis shows that the level of benefits associated with the hydro project increases as energy costs rise. The economic efficiency of the hydro project (compared to a thermal alternative) is enhanced. The results of the relative price shift analysis are displayed in Table 18.

TABLE 18

RELATIVE PRICE SHIFT ANALYSIS

Without Relative Price Shift			With Relative Price Shift		
Energy Value (Mills/Kwh)	Total Benefits ($)	Benefit/Cost Ratio	Energy Value (Mills/Kwh)	Total Benefits ($)	Benefit/Cost Ratio
		Alternative 1			
40	324,000	.74	49.6	401,800	.92
50	405,000	.93	62.0	502,200	1.15
60	486,000	1.12	74.5	603,500	1.39
70	567,000	1.35	86.9	703,900	1.62
80	648,000	1.49	99.1	802,700	1.84
		Alternative 2			
40	544,000	1.16	49.6	674,600	1.44
50	680,000	1.45	62.0	843,200	1.80
60	816,000	1.74	74.5	1,013,200	2.16
70	952,000	2.03	86.9	1,181,800	2.52
80	1,088,000	2.32	99.1	1,347,800	2.87
		Alternative 4			
40	756,000	1.02	49.6	937,400	1.26
50	945,000	1.27	62.0	1,171,800	1.58
60	1,134,000	1.53	74.5	1,408,100	1.90
70	1,323,000	1.78	86.9	1,642,400	2.21
80	1,512,000	2.04	99.1	1,873,000	2.52

MARKETABILITY

The electrical energy produced at Colebrook River Lake would not be sold by the Corps of Engineers. Under Federal law, power generated at Corps projects is marketed by the Department of Energy to public bodies, power cooperatives and private utilities. Although electricity is not sold directly to the consumer, the underlying goal of all Corps hydroelectric projects is to provide power to consumers at the lowest possible rates. Rates are set by the marketing agency and approved by the Federal Energy Regulatory Commission. The marketing agency that would serve New England would be established at some future time.

PROJECT FEASIBILITY

The installed capacity and annual energy production of each alternative is relatively small when compared to total system load. Therefore variations in the operation of either alternative would have little or no impact on the operation of the total power system. In effect the output of the alternatives could be classified as secondary energy, usable for thermal energy displacement whenever energy is available. At present, Alternative 1 would displace 11,400 barrels of oil per year; Alternatives 2 and 3 19,200 barrels; Alternatives 4 and 5 26,700 barrels of oil yearly.

Examination of the B/C criteria shows that for all but one of the alternatives, ratios exceed unity even at the lowest energy values. Table 19 below presents a sensitivity analysis that indicates at what value energy would have to be sold for each alternative to be economically justified.

TABLE 19

ECONOMIC JUSTIFICATION

	Energy Value (Mills/Kwh)	Annual Benefit* ($)	Annual Cost ($)	Benefit Cost Ratio
Alternative 1	40	324,000	435,700	.74
(Energy=8,100 Mwh)	50	405,000	435,700	.93
	60	486,000	435,700	1.12
	53.8	435,700	435,700	1.00
Alternative 2	40	544,000	469,200	1.16
(Energy=13,600 Mwh)	34.5	469,200	469,200	1.00
Alternative 4	40	756,000	742,500	1.02
(Energy=18,900 Mwh)	39.3	742,500	742,500	1.00

*Annual Benefit = Energy Value x Energy (Mwh)

Power produced from Alternative 1 would have to be sold at 53.8 mills per Kwh for project justification; Alternative 2 at 34.5 mills per Kwh; Alternative 4 at 39.3 mills per Kwh for economic justification.

For Alternatives 3 and 5 reversible turbines would be included for more flexible and dependable project operation. Physical conditions at the project site appear favorable for pumped storage. As the study progresses, further analysis may enable a quantification of the value of the dependable capacity provided. Table 20 displays the incremental costs that would be incurred if dependable capacity were included.

TABLE 20

COST OF DEPENDABLE CAPACITY

	Alternative 3	Alternative 2	Incremental Cost
Annual Cost	\$537,500 -	\$469,200 =	\$68,300
Dependable Capacity	2,000 Kw		
Cost Per Kw of Dependable Capacity (Alternative 3)			$\frac{68,300}{2,000}$ = \$34.15
	Alternative 5	**Alternative 4**	**Incremental Cost**
Annual Cost	\$809,400 -	\$742,500 =	\$66,900
Dependable Capacity	2,500 Kw		
Cost Per Kw of Dependable Capacity (Alternative 5)			$\frac{66,900}{2,500}$ = \$26.76

Public Participation Program

OBJECTIVES

The public participation program is intended to provide a continuous two-way communication process to maximize the opportunity for the public to be involved in overall planning, to be aware of the study progress, and to make decisions that would impact on their social well-being. In its broadest sense, the "public" would consist of non-Corps of Engineers entities, such as, Federal, State, local and regional agencies as well as public and private organizations and individual citizens. Inasmuch as major decisions made thoughout the conduct of the study would be based upon some expressed needs and desires of local, county, State and regional officials and the general public, it is necessary to establish a mechanism to channel information to interested participants and to funnel their responses to those responsible for conducting the study, which in this case is the New England Division, Corps of Engineers.

STRATEGY

To be effective a public involvement program must be continuous throughout the entire planning procedure. Major components constituting a productive program are: dissemination of information through brochures, information sheets and reports; solicitation of responses through mail-back forms and discussions, meetings and workshops; utilization of the media to publicize events and information; and cooperation of the public with a study advisory committee.

Total adherence to each of those elements is a policy promulgated for all Corps planning studies. However, upon initiation of this preliminary feasibility study, there was general agreement that certain modification to the public involvement program would be required to accelerate the study program. Using that approach caution would have to be taken that the planning objectives established under the Water Resources Council's Principles and Standards and the National Environmental Policy Act were not violated and that the process would also be totally responsive to the nation's energy needs and objectives.

The strategy devised for the public involvement program and for evaluation of the project viability included the following basic assumptions and criteria:

1. The addition of hydropower at Colebrook would be site specific, rather than an investigation of basin-wide resources.

2. The project study would have to determine the engineering practicability and economic feasibility of the added purpose. If positive results were generated, a fast-track policy involving an accelerated planning process combining Stages 1 and 2 would be established with appropriate recommendations. Otherwise, further studies including an expanded public involvement program would be obviated thereby resulting in a savings in time and funds.

3. The study would be coordinated with the Hartford MDC, State agencies of both Massachusetts and Connecticut and public and municipal electric agencies. It should be noted that during the study process, the Connecticut River Flood Control Compact Commission and the Honorable Anthony T. Moffet's office of the 6th Connecticut Congressional District were apprised of the study findings.

Total future commitment to the public involvement program for Stage 3 will be expanded in accordance with stated objectives upon release of the preliminary feasibility report to the public in February 1981. At such time, the Corps will coordinate its work with the involved States, the Hartford MDC, local officials and the public who will be apprised of the study progress. During Stage 3, the Corps will use the media for the dissemination of progress information. Meetings with all concerned parties will be held at appropriate times as a forum for the exchange of ideas. Although the public involvement activities will concentrate on identifying and evaluating all the possible impacts that would be associated with the most likely selected alternative plan, the involvement process will not preclude or obviate other alternatives currently considered marginally justified and/or unacceptable.

Public response on the various alternatives will be sought so that the final plan selected as the most likely viable alternative is truly in the best interest of the public. Any areas of disagreement including trade-off analyses based on subjective judgment will be considered and resolved to reflect public preferences, mutual satisfaction and total acceptability.

Conclusions

DISCUSSION

As shown by the benefit-to-cost analysis, two of the five alternatives are economically justified, namely, Alternatives 2 and 4. The former, having minor socioeconomic and environmental impacts, could possibly maximize net benefits. The latter would optimize the energy production of the site but the incurred socioeconomic and environmental damages would be far more pronounced and objectionable.

With the introduction of the relative price shift concept, the rising cost of fuel, and the possible exclusion of the proposed steel liner within the existing 10-foot conduit, even Alternative 1, currently having a marginal B/C ratio, could become financially favorable with further study refinements. If credit for dependable capacity were allowed, either as a benefit or credit reduction in project costs, retention of Alternatives 3 and 5 to supersede Alternatives 2 and 4, respectively, for further evaluation would be warranted.

Although Alternative 2 appears to be the most logical choice for further evaluation, it would be premature to obviate all other alternatives at this time. Neither would it be judicious to categorize Alternative 2 as the plan that should be ultimately implemented. That final decision should rest with the next study phase, Stage 3. At such time, power values would be officially determined and finalized by DOE. Then an economic analysis of comparative costs and benefits for all alternatives, supplemented by input from a public involvement program and from the environmental assessment, would provide the proper forum for a final determination of the most justifiable and acceptable alternative. Pending a final determination, Alternative 2 is being retained as the most favorable likely alternative at this time.

The electric hydropower generation to be produced by Alternative 2, as well as by all other alternatives, would originate from the proposed powerhouse to be located at the exit of the existing outlet conduit. With a vertical Kaplan unit and a 90-foot design head, Alternative 2 would provide a 3.5 Mw installation, resulting in a design hydraulic capacity of 570 cfs. The computed average annual energy generation would be about 13,600 Mwh at an average annual plant factor of 44 percent.

As estimated, the total project investment cost is $5,720,000 with annual charges of $469,200, reflecting an energy cost of approximately 34.5 mills/Kwh. The oil displacement would be 19,200 barrels annually. Table 21 presents a summarized version of this data as applicable to all alternatives.

TABLE 21

COMPARATIVE DATA

Alternative	Turbine Type	Capacity (cfs)	Capacity (Mw)	Design Head (ft)	Annual Energy (Mwh)	Oil Savings (barrels)	Investment Cost ($1000)	Annual Charges ($)	Energy Cost (Mills/Kwh)	Remarks ($/Kw)
1	Vertical Kaplan	614	2.5	60	8,100	11,400	5,280	435,700	53.8	
2	Vertical Kaplan	570	3.5	90	13,600	19,200	5,720	469,200	34.5	
3	Reversible Pump	570	3.5	90	13,600	19,200	6,540	537,500	--	34.15*
4	Vertical Kaplan	590	4.0	100	18,900	26,700	9,280	742,500	39.3	
5	Reversible Pump	590	4.0	100	18,900	26,700	10,080	809,400	--	26.76*

*Represents the unit value ($/Kw) required for economic justification were dependable capacity included.

RECOMMENDATION

The installed capacity and annual energy production to be derived from any of the five alternatives evaluated at Colebrook River Lake is relatively small when compared to the total system load. Variations in the mode of operation would also have little or no impact on the operation of the total power system. In effect, the output of any of the alternatives is considered principally an energy producing, "fuel saving" type project that could be classified as secondary energy, usable for thermal energy displacement.

In considering the oil equivalency saved annually, any amount, as shown in Table 21, for each alternative is miniscule as compared to the total annual consumptive use of the region. However, if the region is to eventually achieve self-sufficiency in energy, thereby unshackling itself from its dependency on foreign oil, this hydropower potential could be a step in that direction.

That contention would further be supported by results of the economic analysis derived from this study. Those results indicate that hydropower as an addition to the Colebrook River Lake project is economically justified, and can be socially and environmentally acceptable when involving Alternative 2. However, as previously noted, it would also be premature to dismiss the other alternatives at this time without further refinement.

Therefore, it is imperative that this current preliminary feasibility study, comprising Stages 1 and 2, be expeditiously expanded to include Stage 3, the feasibility study portion of the planning process. As envisioned, efforts of the Stage 3 planning process will concentrate on three major elements: a public involvement program; expansion on the environmental considerations including an Environmental Impact Statement (EIS), if one is deemed required; and the refinement and finalization of the benefit/cost analysis of all five alternatives. The results would permit the ranking of the alternatives not solely on their economic merits, but in accordance with public acceptability, and in harmony with the natural values and environmental enhancement of the project area. The final selected plan should then be subsequently recommended for implementation.

Appendices

APPENDIX A

The Commonwealth of Massachusetts
Division of Fisheries and Wildlife
Leverett Saltonstall Building, Government Center
100 Cambridge Street, Boston 02202

Richard Cronin,
DIRECTOR
Stephen T. Chmura,
Commissioner

September 26, 1980

Mr. Joseph L. Ignazio
Chief, Planning Division
Corps of Engineers
424 Trapelo Rd.
Waltham, MA 02154

Dear Mr. Ignazio:

In response to your recent inquiry relative to the proposed hydro development at Colebrook Reservoir. My staff has reviewed the preliminary information and is of the opinion that the development project as outlined, especially by alternatives 2 and 3, does not pose any detrimental impact to the future quality of the recreational fishery. They do agree that the public access facility will have to be modified in response to the increased elevation of the lake.

Thank you very much for including us at this stage of the planning effort. If we can be of further assistance, please don't hesitate to contact us.

Sincerely

Steve T. Chmura,
Commissioner

STC:dk

cc: Lou Schlotterbeck

APPENDIX B

State of Connecticut

Department of Environmental Protection

State Office Building Hartford, Connecticut 06115

Stanley J. Pac
Commissioner

October 7, 1980

Mr. Joseph L. Ignazio
Chief, Planning Division
Department of the Army
New England Division
Corps of Engineers
424 Trapelo Road
Waltham, MA 02154

Dear Mr. Ignazio:

The following is in response to your letter concerning development of the hydropower potential of the flood control facilities at Colebrook River Lake. These comments are intended to assist your office in preparing a comprehensive evaluation of this proposal. Our comments are directed toward preferred Alternatives 2 and 3 and are commensurate with the level of information and detail provided.

The West Branch Farmington River, which is impounded by Colebrook and Goodwin Dams, is classified as AA in the Connecticut Water Quality Standards and Classifications. This is Connecticut's highest water quality designation and signifies that it is suitable for drinking and part of the Metropolitan District Commission's (MDC) supply network for the Hartford area. The water supply allocation at the dams is not presently being diverted to this system, but is projected to be required within a decade. Preventing any deterioration in water quality which would interfere with this intended use is our primary concern.

Our general water resource concerns related to all hydropower facilities involves maintenance of dissolved oxygen levels, stream flows and eutrophication. In this situation, increases in turbidity appear to represent the greatest potential adverse effect on water quality. The shoreline exposed in lowering the Goodwin Dam impoundment by 31 feet and the projected daily fluctuation of the pool by 6 feet both have the potential of increasing turbidity levels substantially through erosion. An evaluation of the soils, slopes, revegetation potential and the planned operation of the impoundment by MDC will be necessary to assess this issue.

Modification of the permanent elevation of the impoundment pools will cause a disruption of terrestrial habitat. Whether this disruption is considered adverse or beneficial is dependent upon the quality and nature of the localized areas affected and their relationship to the surrounding area. The functional relationship of these areas to the local fauna should also be considered.

Public access to all types of waterbodies has been identified in the State Comprehensive Outdoor Recreation Plan as a major statewide recreational need. Details of the preferred alternatives indicate that use of the existing boat launching facility at Colebrook would be impeded. Maintaining this type of access is a high recreational priority of DEP and should be considered and evaluated thoroughly.

At this point, the Department does not anticipate that environmental issues should preclude development of this hydropower facility. The details that will be developed by advancing this proposal coupled with appropriate mitigation measures should satisfy our principle concerns.

If DEP can be of any additional assistance regarding this project please contact Brian Emerick, of my staff, at 203-566-3740.

Sincerely,

Stanley J Pac

Stanley J Pac

SJP:BJE:bj

APPENDIX C

MMWEC
Massachusetts Municipal Wholesale Electric Company
PUBLIC CORPORATION

July 18, 1980

Max B. Scheider, Col., Div. Eng.
Department of the Army
New England Division, Corps of Engs.
424 Trapelo Road
Waltham, MA 02154

Dear Colonel Scheider:

Recently, we received a telephone inquiry from Mr. Leo Millett of your Division concerning our interest in purchasing power from a proposed 3.5 MW hydroelectric project at the Colebrook Reservoir, on the Farmington River.

We wish to inform you that such a project would be of great interest to us and we would consider purchasing power from it or any similar project subject, of course, to its being an economic and competitive resource.

We have contacted the Connecticut Municipal Energy Cooperative ("CMEEC") of Groton, Connecticut, our counterpart in Connecticut, apprising them of the proposed project. They also expressed an interest in discussing the purchase of power from the facility.

We would therefore recommend that a joint power purchase by both MMWEC and CMEEC be considered in your planning of this project.

If we may be of further assistance in helping you to develop your plans, please do not hesitate to contact me.

Sincerely,

T.H. Roger

Thomas H. Roger, Division Manager
Power Management Division

THR/mb

cc: Phillip C. Otness
Walter Truitt
Bruce McKinnon

STONY BROOK ENERGY CENTER • POST OFFICE BOX 426 • LUDLOW, MASSACHUSETTS 01056 • (413) 589-0141

Phillip C. Otness
General Manager and Secretary

Chairman, Board of Directors James E. Baker
President F.H. King
Treasurer George E. Leary
General Counsel Maurice J. Ferriter

APPENDIX D

This is a copy of the contract between the United States and the Metropolitan District for water storage space in the Colebrook River Lake Reservoir, entered into 11 February 1965.

CONTRACT BETWEEN THE UNITED STATES OF AMERICA
AND
THE METROPOLITAN DISTRICT
FOR
WATER STORAGE SPACE IN COLEBROOK RIVER RESERVOIR

THIS CONTRACT, entered into this 11th day of February, 1965, by and between the UNITED STATES OF AMERICA (hereinafter called the Government), represented by the Contracting Officer executing this contract, and THE METROPOLITAN DISTRICT, a Municipal Corporation, with its principal office in the City of Hartford, Connecticut (hereinafter called the District)

WITNESSETH THAT:

1. WHEREAS, construction of the Colebrook River Reservoir on the West Branch of the Farmington River, Connecticut and Massachusetts, (hereinafter called the Project) has been authorized by the Act approved 14 July 1960 (Public Law 86-645) in accordance with recommendations of the Chief of Engineers in House Document No. 443 (86th Congress, 2nd Session); and,

2. WHEREAS, the Metropolitan District, a Municipal Corporation in the State of Connecticut, is empowered under the provisions of Special Act No. 122 of the January Session, 1963 General Assembly, to make agreements with the United States in connection with the Colebrook River Project and to divert further water from the West Branch of the Farmington River; and,

3. WHEREAS, the Government is authorized by the Water Supply Act of 1958, Title III of Public Law 85-500, approved 3 July 1958, as amended by Section 10 of the Federal Water Pollution Control Act, Amendments of 1961, Public Law 87-88, to include storage in any reservoir project to be constructed by the Corps of Engineers to impound water for present or anticipated future demand or need for municipal or industrial water; and,

4. WHEREAS, Public Law 88-140, approved 16 October 1963 makes permanent the rights of States and local interests to utilize municipal and industrial storage in Corps of Engineers reservoirs for which they have contributed or will hereafter contribute or have contracted or will hereafter contract to pay the Government, over a specified period of years, money, exclusive of interest, equivalent to the cost of providing a space for such storage; and,

5. WHEREAS, storage space has been included in the project for municipal and industrial water between Elevations 701 and 644 feet above mean sea level; and,

6. WHEREAS, the District anticipates that a portion of the storage space designated for future use will be required immediately upon completion of the Project and that all of such storage space will be required on or before 1 January 1978; and,

7. WHEREAS, the District desires to utilize the storage space between Elevations 677 and 644 feet above mean sea level (hereinafter called storage space #1), as a source of present water supply as set forth in Article 1; and,

8. WHEREAS, the District desires to utilize the storage space between Elevations 701 and 677 feet above mean sea level (hereinafter called storage space #2) for future water supply; and,

9. WHEREAS, the cost of storage space #2 does not exceed 30% of the total estimated construction cost of the project; and,

10. WHEREAS, the District has furnished reasonable assurances that demands for the use of storage space #2 will be met within a period of time which will permit paying out the costs allocated to water supply within the life of the project; and,

11. WHEREAS, the District hereby agrees to fulfill the local interest requirements of the project authorization, applicable to water supply, as set forth herein.

NOW, THEREFORE, THE PARTIES DO MUTUALLY AGREE AS FOLLOWS:

ARTICLE 1. <u>WATER STORAGE SPACE</u>

a. The District shall have the right to utilize storage space No. 1 (between 677 and 644 feet above mean sea level) for a present water supply for municipal and industrial use and low flow improvement as deemed necessary by the District, to impound water in the Project and make such diversions as granted to the District by the State of Connecticut to the extent that such storage will provide.

b. The District shall have the right to withdraw water from the aforesaid storage space or to order releases therefrom to be made by the Government at any time so long as sufficient storage is available within the aforesaid storage space to permit direct releases through the outlet tunnel in the dam abutment provided that no such releases will be made which would cause flooding when combined with local runoff below the dam.

c. The District shall have the right to utilize the successive increments of storage space No. 2 (between 701 and 677 feet above mean sea level) in the same manner as storage space No. 1 upon making the first payment on the principal thereon as provided in Article 7.

d. The Government shall not be responsible for diversion by others, nor will it become a party to any controversies between users of the aforesaid storage space.

e. The Government reserves the right to take such measures as may be necessary in the operation of the project to preserve life and/or property.

f. The Government shall have the right to utilize any of the unused aforesaid storage space below Elevation 701.0 for storage of water on behalf of the State of Connecticut for in-reservoir fisheries, for downstream sport fishery improvements or other purposes. The District shall have the right to fully occupy such aforesaid storage space when sufficient water is available.

g. Payment for the present storage, including operating and maintenance therefor, will commence immediately upon initiation of deliberate impoundment. The term "deliberate impoundment" as used in this contract shall mean the date upon which the project becomes operative for storage of water for any of its authorized purposes.

ARTICLE 2. SEDIMENTATION AND DEAD STORAGE

The District shall reserve the storage space below Elevation 598.0 for dead storage and as reserve capacity for storage of sediment. When sedimentation resurveys are made, the storage space so reserved shall be reallocated if necessary to replace any storage space above or below Elevation 701 which may be lost due to sedimentation. Storage space between Elevations 641.0 and 644.0 shall be considered a replacement for this reserve capacity.

ARTICLE 3. HOLDOVER STORAGE

The future plans of the District provide for the construction of a tunnel from the Goodwin Dam to the Barkhamsted Water Supply Reservoir and diversion of the stored water for District use. The District shall, at such time as substantial amounts of the stored water are diverted, either by means of the proposed tunnel or otherwise, operate its storage in such a manner as to maintain 5,000 acre-feet of water between elevation 625.0 and 598.0 in the Colebrook River Reservoir as holdover storage. The holdover storage will not be used except in cases of emergency as determined by the District and will not be included in the District's normal reserve storage required to fulfill minimum flow release requirements.

ARTICLE 4. EXISTING WATER STORAGE SPACE

Except as provided in Articles 2 and 3 above, nothing in this agreement shall affect the existing rights of the District to utilize the storage space below Elevation 641.0, the elevation of the spillway crest at Goodwin Dam.

ARTICLE 5. MEASUREMENT

a. For the purpose of maintaining accurate records of water stages at the Project, the Government shall install suitable float well gages. The Government will also furnish the District periodically, at least monthly, a record of all reservoir stages in the Project.

b. The District shall cooperate with the Government and the Connecticut Board of Fisheries and Game in maintaining accurate records of water used at the Project. The District shall furnish the Government monthly statements showing the amount and duration of releases made at the Goodwin Dam for each purpose.

c. The District, prior to use of the water storage space for domestic purposes, agrees to install a suitable weir or other metering devices satisfactory to the Contracting Officer without cost to the Government. Unless otherwise provided, such weir will be installed at the discharge end of the proposed diversion tunnel between Goodwin Dam and Barkhamsted Reservoir. The District shall furnish the Government monthly statements showing the amount and duration of such diversion.

ARTICLE 6. REGULATION OF THE USE OF WATER

The regulation of the use of water stored in the aforesaid storage spaces between Elevations 701.0 and 598.0 shall be the responsibility of the District and shall not be considered a part of this contract. Gate operation required for reservoir releases as ordered by the District will be accomplished by the Government.

ARTICLE 7. CONSIDERATION AND PAYMENT

In consideration of the payments provided in this agreement to be paid by the District to the Government, the Government will provide storage spaces in the Project as provided in Article 1. In consideration of the Government's providing the aforesaid storage spaces to the District, the District shall pay the following sums to the Government:

a. The sum of $5,587,085.48 which is the total estimated cost of providing all water storage space including interest during construction at the rate of three and one hundred thirty-seven thousandths percent (3.137%) per annum. The sum of $5,587,085.48 represents 35.49

percent of the total estimated investment cost of the joint use facilities together with 75.43 percent of the specific cost of reservoir clearing. Payments shall be made in the following manner:

(1) A payment in the amount of $108,024.77 shall be made on 1 January 1968 and annually thereafter on 1 January of each year up to and including 1 January 2017. The date of 1 January 1968 is based on the assumption that Storage Space No. 1 will be available on or about this date. The $108,024.77 is the annual payment necessary to liquidate the $2,793,542.74 estimate of cost of Storage Space No. 1 in a period of 50 years with an interest rate of 3.137% per annum on the unpaid balance. In the event that the date of deliberate impoundment is delayed beyond 1 March 1968, the schedule of payments for Storage Space No. 1 shall be delayed to the same extent.

(2) A payment in the amount of $71,296.35 shall be made on 1 January 1973 and annually thereafter on 1 January of each year up to and including 1 January 2022. The date of 1 January 1973 is based on the assumption that the first increment of Storage Space No. 2, estimated to cost $1,843,738.21 will be used starting as of this date. The $71,296.35 is the annual payment necessary to liquidate $1,843,738.21 estimate of cost of this first increment of Storage Space No. 2 in a period of 50 years with an interest rate of 3.137% per annum on the unpaid balance. No payments on the investment of $1,843,738.21 are required until the date of 1 January 1973 when it is assumed the use of this storage of water will be made. The period of 5 years from 1 January 1968 to 1 January 1973 is interest free.

(3) A payment in the amount of $36,728.42 shall be made on 1 January 1978 and annually thereafter on 1 January of each year up to and including 1 January 2027. The date of 1 January 1978 is based on the assumption that the final increment of Storage Space No. 2, estimated to cost $949,804.53 will be used starting as of this date. The $36,728.42 is the annual payment necessary to liquidate the $949,804.53 estimate of cost of the second and final increment of Storage Space No. 2 in a period of 50 years with an interest rate of 3.137% per annum on the unpaid balance.

b. The aforesaid payments are more specifically set forth in Exhibit "A" attached hereto and made a part hereof, and the last payment of items a, (1)-(3) above shall be adjusted upward and downward when due, to assure the repayment of all capital costs and interest within their respective 50-year periods, in the following manner:

(1) In the event the actual first cost of the Project exceeds the presently estimated first cost the aforesaid annual payments shall be increased to reflect the actual first cost, including interest during construction, as determined by the Contracting Officer. In the event such first cost of the Project is less than presently estimated

first cost the aforesaid annual payments shall be decreased to reflect the actual first cost, including interest during construction, as determined by the Contracting Officer.

(2) In the event the annual payments are increased or decreased, as provided above, an adjustment, as determined by the Contracting Officer, of payments made prior to the determination of the final Project cost shall be made in the first payment due after such costs are determined. At the time that the final Project costs are determined, Exhibit "A" shall be modified to reflect the increased or decreased annual payments and such modification will form a part of this contract.

c. Prior to the date of deliberate impoundment, the District may increase or decrease the amount of capacity included in Storage Space No. 1 with a corresponding change in Storage Space No. 2 provided that the cost of Storage Space No. 2 shall not be increased above 30 percent of the total project cost as determined by the Contracting Officer.

(1) The District may vary the size and time of taking of the increments in Storage Space No. 2 including additional increments if desired. The total number of such increments shall not exceed four. In the event any increments are not taken by 1 January 1978, the cost of such increments shall bear interest at the rate of three and one hundred thirty-seven thousandths percent (3.137%) from 1 January 1978 or ten years after the date of deliberate impoundment, whichever shall be the later. Taking of the final increment shall not be delayed beyond 1 January 2018 or 50 years after the date of deliberate impoundment, whichever shall be the later.

d. The District shall have the right if it so elects to make additional principal payments so as to discharge or reduce the indebtedness, as indicated in Exhibit "A". Any additional number of principal payments must be in the amount and order designated in Columns 3 of Exhibit "A", but may be made on Schedule 1, 2 or 3 or any combination thereof. Any such payments shall be made at the same time the annual installments are paid. Payment by the District of such additional principal payments shall relieve the District of the interest charges corresponding to such additional principal payments as shown in column 2 (payment to interest) of Exhibit "A". Such additional principal payments shall not preclude payment of the subsequent annual installments as set forth in Exhibit "A".

e. <u>The annual experienced joint use cost of ordinary operation and maintenance of the project allocated to water supply.</u>

(1) The first payment estimated to be $5,700.00 will be due and payable on 1 January 1968. Annual payments will be due and

payable in advance on the first day of January thereafter and will be equal to the allocated portion of the actual experienced joint use cost of ordinary operation and maintenance for the preceding Government fiscal year. The second payment shall be increased or decreased in an amount to reflect the difference between the first payment and the actual allocated portion of the experienced joint use cost of ordinary operation and maintenance for the preceding fiscal year. The joint use costs shall be allocated on the basis of the amount of storage taken by the District in the following manner:

(a) From 1 January 1968 to 31 December 1972, 17.75 percent.

(b) From 1 January 1973 to 31 December 1977, 29.46 percent.

(c) On 1 January 1978 and thereafter, 35.49 percent.

(2) The above percentages are based on the assumption that the District will utilize 5 billion gallons of storage space on or about 1 January 1968; a second increment of 3.3 billion gallons in 1973 and a final increment of 1.7 billion gallons in 1978. If the utilization by the District is modified, the above percentages shall be modified proportionately.

(3) Records of cost of operation and maintenance of the Project shall be available for inspection and examination by the District. However, the extent of operation and maintenance of the Project shall be determined by the Contracting Officer and all records and accounting shall be maintained by the Contracting Officer. In the event the District should require additional operation for the water supply storage over and above that deemed necessary by the Contracting Officer, the District shall bear the entire cost of such additional expense.

f. The District shall pay 35.49 percent of the cost of sedimentation resurveys and major capital replacements when incurred. In the event such costs are incurred before the District takes all its storage, the cost shall be adjusted proportionately.

g. In the event of default in the payment of the costs contained in Article 7, a - f, the amount of such payments shall be increased by an amount equal to interest on such overdue payments at the rate of three and one hundred thirty-seven thousandths percent (3.137%) per annum thereon; compounded annually, and such amount equal to interest shall be charged from the date such payments are due until paid.

ARTICLE 8. PERIOD OF CONTRACT

This contract shall become effective as of the date of approval by the Secretary of the Army or his duly authorized representative and shall continue in full force and effect under the conditions set forth herein not to exceed the life of the project.

ARTICLE 9. PERMANENT RIGHTS TO STORAGE

Upon completion of payments by the District, as provided in Article 7 herein, the District shall have a permanent right under the provisions of P. L. 88-140 to the use of such storage space in the project, as provided in Article 1 herein, subject to the following:

a. The District must have discharged its responsibilities for payment of the costs allocated to water supply.

b. The District must continue payment of annual operation and maintenance costs allocated to water supply.

c. The District must pay in lump sum, or annually with interest at the rate of 3.137% the costs allocated to water supply which may, at termination of the pay-out periods set forth in Article 7 above, be required for any necessary reconstruction, rehabilitation or replacement of project features which may be required to continue satisfactory operation of the project. Such costs will be established by the Contracting Officer. Repayment arrangements (or schedules) will be in writing and will be made a part of this contract by supplemental agreement.

d. Upon completion of payments by the District, as provided in Article 7 above, the Contracting Officer shall redetermine the storage space for municipal and industrial water supply, taking into account such equitable reallocation of reservoir storage capacities among the purposes served by the project as may be necessary due to sedimentation. Such findings, and the storage space allocated to municipal and industrial water supply shall be defined and described in an exhibit which will be made a part of this contract by supplemental agreement. Following the same principle, such reallocation of reservoir storage capacity may be further adjusted from time to time as the result of sedimentation resurveys to reflect actual rates of sedimentation and the exhibit revised to show the revised storage space allocated to municipal and industrial water supply.

e. The permanent rights of the District shall be continued so long as the Government continues to operate the project. In the event the Government no longer operates the project, such rights may be continued subject to the execution of a separate contract, or supplemental agreement providing for:

(1) Continued operation by the District of such part of the facility as is necessary for utilization of the storage space allocated to it;

(2) Terms which will protect the public interest;

(3) Effective absolvement of the Government by the District from all liability in connection with such continued operation.

ARTICLE 10. DEFAULT

In the event the District refuses or fails to comply with the provisions of this contract with respect to transfer and assignment, or if it fails to make payments as provided herein within a reasonable time, then the Government reserves the right to terminate this contract. (See Article 7, subpar. g)

ARTICLE 11. OPERATION AND MAINTENANCE

The Government shall operate and maintain the Project owned by the Government. The District shall have the right to make withdrawals of water for its purposes as needed in accordance with Article 1. The District shall be responsible for operation and maintenance of all features and appurtenances which may be provided and owned by the District. In the event the Government should suspend operation and maintenance of the Project, during the period of this contract, due to lack of appropriated funds, then and in that event the District shall be privileged and shall have the right to enter upon the premises and operate the same for its own use and benefit in supplying itself with water to the extent provided in this contract.

ARTICLE 12. TRANSFER AND ASSIGNMENT

The District shall not transfer or assign this contract nor any rights acquired thereunder, nor suballot said water or storage space or any part thereof, nor grant any interest, privilege or license whatsoever in connection with this contract, without the approval of the Secretary of the Army or his authorized representative; provided that, unless contrary to the public interest, this restriction shall not be construed to apply to any water which may be obtained from the water supply storage space by the District and furnished to any third party or parties.

ARTICLE 13. RELEASE OF CLAIMS

The District shall hold and save the Government, including its officers, agencies and employees, harmless from liability of any nature or kind for or on account of any claim for damages which may be filed or asserted as a result of the water supply storage in the Project, or withdrawal or release of such water from the Project,made or ordered by the District, or as a result of the construction, operation, or maintenance of the appurtenances owned and operated by the District.

ARTICLE 14. FEDERAL AND STATE LAWS

The District shall utilize such storage space in a manner consistent with Federal and State laws.

ARTICLE 15. OFFICIALS NOT TO BENEFIT (ASPR 7-103.19)

No member of or delegate to Congress, or resident commissioner, shall be admitted to any share or part of this contract, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this contract if made with a corporation for its general benefit.

ARTICLE 16. COVENANT AGAINST CONTINGENT FEES (ASPR 7-103.20)

The District warrants that no person or selling agency has been employed or retained to solicit or secure this contract upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bona fide established commercial or selling agencies maintained by the District for the purpose of securing business. For breach or violation of this warranty the Government shall have the right to annul this contract without liability or in its discretion to add to the contract price or consideration, or otherwise recover, the full amount of such commission, percentage, brokerage, or contingent fee.

ARTICLE 17. APPROVAL OF CONTRACT

This contract shall be subject to the written approval of the Secretary of the Army or his duly authorized representative and shall not be binding until so approved.

IN WITNESS WHEREOF, the parties hereto have executed this contract as of the day and year first above written.

THE UNITED STATES OF AMERICA

By [signature]
E. J. REBBS
Colonel, Corps of Engineers
Acting Division Engineer
Contracting Officer

TWO WITNESSES:

Nicholas Bonadies
Name

145 Barker St. Htfd. Conn.
Address

Helen M Cavanaugh
Name

324 Warren ST
Address New Britain, Ct

THE METROPOLITAN DISTRICT

By Edward J. McDonough Jr.
EDWARD J. McDONOUGH
Chairman of its District Board

Corporate Seal

CERTIFICATE

I, Gerard R. d'Avignon, certify that I am the District Clerk of The Metropolitan District; that Edward J. McDonough who signed this contract on behalf of The Metropolitan District was then Chairman of its District Board; that said contract was duly signed for and on behalf of The Metropolitan District by authority of its governing body and is within the scope of its corporate powers.

IN WITNESS WHEREOF, I have hereunto affixed my hand and the seal of said corporation this 11th day of February 1965.

Gerard R. d'Avignon
District Clerk

Corporate Seal

Approved as to form and content for The Metropolitan District.

Alfred F. Wechsler
ALFRED F. WECHSLER
District Counsel

APPROVED:

Stephen Ailes
SECRETARY OF THE ARMY

DATE: 10 MAR 1965

APPENDIX E

This is a copy of the Riparian Agreement between the Metropolitan District and the riparian owners, which was signed by all concerned on 13 July 1961.

ADDENDUM

(Minutes of The Metropolitan District Commission, July 10, 1961)

Water Bureau
RIPARIAN AGREEMENT
The Farmington River Power Company
The Collins Company
The Hartford Electric Light Company
The Riparian Company

At its meeting held on June 5, 1961, the District Board approved and authorized the District Chairman to sign a revised agreement with The Riparian Owners.

On July 13, 1961, this revised agreement was signed by all concerned, a copy of which follows:

RIPARIAN AGREEMENT

MEMORANDUM OF AGREEMENT made and concluded this 13th day of July, 1961, by and between The Metropolitan District, a municipal corporation organized and existing under Special Acts of the General Assembly of the State of Connecticut and having territorial limits within the County of Hartford, State of Connecticut, party of the first part, (hereinafter called the "District"): and The Collins Company, The Farmington River Power Company, The Hartford Electric Light Company and The Riparian Company, Connecticut corporations, jointly and severally parties of the second part (hereinafter called the "Riparian Owners" or "Owners"):

Whereas, The District is charged under said several acts with the duty of supplying to the inhabitants of said district and to certain other towns and persons water for domestic and other purposes; and

Whereas, two certain contracts and one Memorandum of Agreement now exist: one contract dated May 1, 1911 by and between The Board of Water Commissioners of the City of Hartford of the State of Connecticut and The Collins Company, The Union Water Power Company and its Lessees, and The Farmington River Power Company; and the other contract dated October 13, 1925 by and between said Water Commissioners and The Collins Company, The Union Electric Light and Power Company, The Farmington River Power Company, and The Riparian Company; and the Memorandum of Agreement dated March 31, 1931 by and between the Metropolitan District and Landers, Frary and Clark, The Collins Company, The Union Electric Light and Power Company, and The Farmington River Power Company; and

Whereas, the District has assumed the performance and obligations under said contracts of said Board of Water Commissioners: and

Whereas, the purpose of said contracts and of said Memorandum of Agreement was to assure to said Riparian Owners and to the inhabitants of the Farmington River Valley a proper and equitable supply of water through the Farmington River and its tributary streams for commercial and other purposes; and

Whereas, there now exist on the Farmington River watershed two reservoirs primarily for District water supply purposes: Nepaug Reservoir on Nepaug River and on Phelps Brook, (tributaries of the Farmington River); and Barkhamsted Reservoir on the East Branch of the Farmington River; and

Whereas, there now exist on the East Branch of the Farmington River a compensating reservoir at Richard's Corner, and a reservoir on the West Branch at Hogback for compensation in kind and ultimately for water supply purposes; and

Whereas, Special Act No. 444 of 1949 of the General Assembly of the State of Connecticut restricts the impounding of the natural flow of the West Branch of the Farmington River at the dam of the Hogback Reservoir to flows in excess of 150 cubic feet per second above the dam site exclusive of any water discharged from the Otis Reservoir watershed; and said Special Act No. 444 specifies that the minimum flow shall not be allowed to fall below 50 cubic feet per second through or over the dam regardless of the actual natural minimum flow; and

Whereas, it is expected that the diversion of water from the said reservoirs and the restrictions noted in said Special Act No. 444 will result in damage to the Riparian Owners at their several mill sites along the Farmington River below the confluence of the East and West Branches thereof; and

Whereas, in the opinion of the parties the ascertainment of these damages in cash will be long, difficult and expensive; and

Whereas, instead of defraying said damages in cash, it is proposed to control the flow of water in said Farmington River by creating a regulated flow, at the cost of the District, through the operation of the Nepaug, the Barkhamsted, the East Branch Compensating and the Hogback Reservoirs; all of which will be in the nature of compensation in kind and in lieu of any cash damages to which the Riparian Owners may be entitled, as well as affording such improvement to the river that the entire community will be benefited; and

Whereas, the District, for its corporate purposes, now desires to enter into a new agreement with the Riparian Owners because certain conditions of the Memorandum of Agreement of March 31, 1931 cannot be met by reason of the restrictions contained in said Special Act No. 444, and because of the impracticability of fulfilling the terms of said Memorandum of Agreement regarding drainage area tributary to the specified compensating reservoir;

NOW THEREFORE, It is agreed:

1. The parties intend by this Agreement to amend the said two contracts and Memorandum of Agreement, and hereby do amend said contracts and Agreement, to the extent necessary to enable the District to provide compensation in kind to the Riparian Owners instead of immediate cash payments, and by improving the river to secure lasting benefits to the community. The agreements, obligations, and performances on the part of the District hereinafter set forth shall inure to the benefit of and be binding in favor of each of the said Riparian Owners, severally, and their respective successors and assigns, owners of the water powers now owned by them.
2. Subject to the limitations hereinafter contained, compensation shall be made by the District to the Riparian Owners through the regulation of flows of water in the Farmington River in the amounts and at the time directed by the Riparian Owners.
3. The total annual amount of such compensation to be made by the District to the Riparian Owners shall be not less than 21.7 billion gallons of water, delivered subject to the following conditions:
   a. Between May 15 and October 31 (both dates inclusive) the District is not obligated to deliver more than 17.4 billion gallons of water. However, nothing herein shall preclude delivery of an additional 0.6 billion gallons in this period by mutual agreement. This additional amount over 17.4 billion gallons shall be credited against the total delivery of 21.7 billion gallons for the water year.
   b. Between November 1 and March 15 of the following year (both dates inclusive) the District is not obligated to deliver more than the total of 4.3 billion gallons of water, and the difference between the amount of compensating water delivered by the District in the preceding May 15 - October 31 period and 17.4 billion gallons of water. However the amount of this difference shall not exceed 3 billion gallons in any single period.
   c. Between March 16 and May 14 of any year (both dates inclusive) the District is not obligated to deliver any water.
   d. The District is not obligated to deliver more than 2.0 billion gallons of water in any calendar week nor more than 400 million gallons in any one day. For the purposes of this agreement a day is defined as the twenty-four hour period beginning at 12:01 o'clock A.M.
   e. The District is not obligated to deliver compensating water at any time at a rate in excess of 800 million gallons of water per day.

f. The compensating water to be delivered by the District to the Riparian Owners shall be from the Nepaug Reservoir, the Barkhamsted Reservoir, the East Branch Compensating Reservoir, and/or the Hogback Reservoir, at the discretion of the District, and shall be delivered to the Riparian Owners and shall be deemed delivered to the Riparian Owners immediately below the dam of the Nepaug Reservoir, the East Branch Compensating Reservoir, and or the Hogback Reservoir, as the case may be.

g. The District, at its cost, shall obtain and furnish such data and shall keep such records as shall be reasonably necessary to enable the parties hereto to determine performance under this agreement. The District will provide the Riparian Owners with copies of such records as the Riparian Owners shall request.

4. The delivery of water by the District in accordance with paragraph 3 above shall be in the nature of compensation in kind and in lieu of any cash damages to which the Riparian Owners may now be entitled, as well as affording such improvement to the river that the entire community will be benefited. In the event of termination of this agreement, as hereinafter provided, the Riparian Owners shall not be deemed to have waived any rights with respect to the kind or amount of compensation to which they are entitled. The acceptance by the Riparian Owners of compensation in kind, pursuant to this agreement, is based upon the presently existing dams and reservoirs of the District and the watershed supporting each such reservoir, except as provided for in paragraph 8.

5. If, on demand, the District fails to deliver at least 17.4 billion gallons of compensating water in the period May 15 through October 31 or the total amount of compensating water which the District is obligated to deliver in the period November 1 through March 15, the District shall compensate the Riparian Owners as soon as possible after demand by the Riparian Owners with electrical energy or cash, computed on each Owner's costs to obtain an amount of electrical energy equivalent to the amount of electrical energy which could have been generated by that Owner with the compensating water which the District had failed to deliver. If for three consecutive periods of May 15 through March 15, the District, on demand, fails to deliver a total of at least 17.5 billion gallons of water per each ten month period, such failure shall indicate the District's inability to fulfill this agreement and the Riparian Owners shall have any and all rights which they now or in the future may have, including without limitation the right to terminate this agreement. The District, moreover, shall compensate the Riparian Owners, with electrical energy or cash as provided in this paragraph.

5. Construction or any other work of the United States Government or the State of Connecticut which prevents the District from delivering at least 17.5 billion gallons in a ten month period of May 15 through March 15 will not be considered an inability on the part of the District to perform under this agreement and such ten month period will not be considered in computing the three consecutive ten month periods hereinabove described, but the District shall be obligated to compensate the Riparian Owners with electrical energy or cash as hereinabove described.
6. If the Riparian Owners do not call on the District to deliver the amounts of water to which the Owners are entitled under this agreement, then the Owners shall have forfeited for that particular water-year (May 15 through March 15) only the water not demanded.
7. Nothing in this agreement shall prevent the District from furnishing all the water required for the needs of its inhabitants and of others who may be entitled thereto, from any or all of the reservoirs listed hereinbefore; and if, in a year of subnormal run-off, it shall become absolutely necessary, in order to supply water to the inhabitants of any territory served by said District for drinking or sanitary purposes, or for such uses as in accordance with present practice would be permitted in times of drought, delivery to the Riparian Owners may be temporarily reduced below 21.7 billion gallons of water as hereinbefore set forth, but in any such case compensation shall be made as provided for in Paragraph 5.
8. Nothing in this agreement shall prevent the District from entering into an agreement with the United States Government or the State of Connecticut for the construction of the dual purpose reservoir (presently under consideration) on the West Branch of the Farmington River upstream from the present Charles A. Goodwin dam; nor shall it prevent the District from constructing a tunnel in transmitting therein water from the Hogback Reservoir to the Barkhamsted Reservoir. The completion of one or both of these projects shall not confer on the Riparian Owners the right of requesting a renegotiation of the agreed upon amounts of water as set forth hereinbefore, but shall not relieve the District from its obligation to deliver not less than 21.7 billion gallons of water as hereinabove set forth or the compensation in lieu thereof as described in paragraph 5 above. The provisions of this paragraph 8 shall not operate as a limitation of the rights retained by the Riparian Owners as described in Paragraph 10 herein.
9. The direction as to amounts and time of delivery of compensation water shall be by the Riparian Owners, who for said purpose may act through the agency of The Riparian Company, (who for such purpose has executed this agreement), or of some similar agent as may be appointed by the Riparian

Owners. The District shall retain the right of choice of source of such compensation water as specified in paragraph 3 and the right to enforce such limitations on operation as are provided herein and as may be reasonably necessary for the protection of its works.

10. The Riparian Owners agree to waive and do hereby waive all their rights at common law and under the provisions of said contracts dated May 1, 1911 and October 13, 1925 and of said Memorandum of Agreement dated March 31, 1931, in respect to the free flow of the East Branch of the Farmington River above the Richard's Corner dam; and to the free flow of the West Branch of the Farmington River above the Charles A. Goodwin dam except for the discharge from the Otis Reservoir watershed and except for the natural flows of the stream up to 150 cubic feet per second at the said Charles A. Goodwin dam, as long as the District, or its successors, shall fully comply with and perform the provisions of this Agreement. This waiver shall not operate to prevent the assertion of any or all such rights by the Riparian Owners if the District defaults in its performance of the provisions of this agreement, and such default shall continue for an unreasonable period.

APPENDIX F

This is a copy of the Riparian Agreement between the Metropolitan District and the Allied Connecticut Towns, Inc., 18 April 1949.

AGREEMENT made this 18th day of April, 1949 by and between The Allied Connecticut Towns, Incorporated, a corporation incorporated under the laws of the State of Connecticut, hereinafter sometimes called the "Corporation", acting herein by Hadleigh H. Howd, its President duly authorized and empowered hereunto by vote of its board of directors, party of the first part, and The Metropolitan District, a municipal corporation specially chartered by the General Assembly of the State of Connecticut, having its territorial limits within the County of Hartford in said state, hereinafter sometimes called the "District", acting herein by Edward N. Allen, its Chairman, duly authorized hereunto by vote of its District Board.

WITNESSETH:

WHEREAS, the District is desirous of building a dam for water supply purposes at the Hogback, so-called, in the Town of Hartland, in Hartford County, in the State of Connecticut, for the purpose of impounding and diverting the waters of the West Branch of the Farmington River for a water supply; and

WHEREAS, the Corporation is a lower riparian owner on said stream; and

WHEREAS, one of the purposes for which said Corporation was formed is to conserve, protect and promote the natural beauties, the natural resources and the recreational facilities of the State of Connecticut; and

WHEREAS, the District owns and operates various other reservoirs which, together with the proposed Hogback reservoir, will have a safe yield of water therefrom sufficient to meet the needs of the inhabitants within its territorial limits for many years to come; and

WHEREAS, the Corporation has opposed the granting of authority by the General Assembly to the District for the purpose of building a dam at said Hogback and the moving of trunk-line highways and the right of eminent domain in connection with the same; and

WHEREAS, various sportsmen's organizations located within the state of Connecticut and allied with the Corporation have also opposed the granting of said authority for the building of said dam as aforesaid because of the limitation of boating, hunting, fishing and other recreational activities which would result from said construction;

NOW THEREFORE:

In consideration of the premises and other valuable considerations the parties hereto agree as follows:

1. The Corporation, as a riparian owner, will not hereafter assert its common law rights as such riparian owner as to the flow of the West Branch of the Farmington River through or along its property but shall be restricted to such riparian rights as it may be entitled to by virtue of this contract.

2. The District has inserted in the so-called Hogback bill, House Bill No. 610, which it has introduced into the General Assembly at its session of 1949, a provision prohibiting the development for water supply purposes of said West Branch of the Farmington River below said Hogback dam site to and including Satan's Kingdom and of Sandy Brook, Mad River and Still River, or of any other tributaries of said West Branch which enter the said river between said points, and the District hereby agrees specifically that for the period of seventy-five (75) years hereafter it will not construct any dam or similar obstruction to said river between said points at any time or attempt to do so, except at Greenwood's Pond as hereinafter provided.

3. The District hereby agrees to have said House Bill amended to the effect that the District shall not have any right of eminent domain in respect to land or property rights upon, beneath, along or bordering said West Branch of the Farmington River from a point immediately below said Hogback dam site to and including Satan's Kingdom, except for the construction, repair and maintenance of pipe lines for water supply purposes.

4. The District further agrees that in the event said riparian proprietors or any of them who are parties to an agreement with The Metropolitan District dated March 31, 1931, shall demand by virtue of said contract that the District shall build any further dam or dams below Hogback dam site on said West Branch of the Farmington River to and including Satan's Kingdom or on any of said tributaries or that the District shall impound for them or any of them any of the water flowing between Hogback dam on said West Branch and above said Satan's Kingdom or in any of said tributaries, the District will invoke the provision in said contract for relief on the part of the Metropolitan District which states, "Nothing in this agreement shall prevent The Metropolitan District from furnishing all the water required for the needs of its inhabitants and of others who may be entitled thereto, . . ." and if the District shall be unable to supply the riparian owners with the amount of water which it may be obligated to furnish by the provisions of said agreement, it will make up the equivalent of such shortage by electrical energy or otherwise.

5. The District agrees that in the event it shall obtain authority for the right of eminent domain from the General Assembly to build said dam and reservoir at Hogback it will allow and permit boating and fishing upon the Hogback reservoir, so-called, and that it will allow and

permit hunting and fishing upon all the watershed area of said Hogback reservoir which may be owned by the District, subject only to such proper rules and regulations as may be promulgated from time to time by a commission of seven members consisting of one member of the State Department of Health to be appointed by the Connecticut Public Health Council, one member of the State Board of Fisheries and Game to be appointed by said Board, one member of the Water Bureau of the District to be appointed by the District chairman and one representative from each of the towns of Colebrook, Barkhamsted, New Hartford and Hartland to be appointed by the Board of Selectmen of each of said towns, such representative as far as possible to be selected from a sportsmen's organization. The members of said commission shall serve without compensation.

6. The District agrees to maintain through or over said Hogback dam a minimum flow of fifty cubic feet per second at all times and to hold back at said dam only such flow of said West Branch as shall be in excess of one hundred fifty cubic feet per second above the dam site exclusive of any water discharged from the Otis reservoir watershed.

7. The District agrees to construct not later than fifteen years after the effective date of said Hogback bill a dam at or near the site of the former dam at Greenwood's Pond, the water impounded thereby to be made available for hunting, fishing and recreation, subject to its use by the District for power or compensation or other purposes but not for drinking or public water supply purposes.

8. The District agrees to explore with the Connecticut Flood Control And Water Policy Commission the possibilities of making use of said Hogback reservoir for flood control purposes by increasing the height of the dam.

9. The District agrees that it will sell to approved purchasers at prices to be agreed upon between the parties, any land owned by it in the West Branch or East Branch areas and located outside the watersheds of said streams and their tributaries which it shall determine to be unnecessary for its District purposes, except land located in that area of the town of Colebrook which lies east of said West Branch, south of the Massachusetts State line and west of the town line of Hartland, and to make available for purchase in the same manner land situated upon any of said watersheds which are so located, that, in its opinion, use of occupancy thereof will not be detrimental to the water supply system under proper regulations.

10. The District agrees that it will use its best efforts to induce the Connecticut State Highway Department to complete, as soon as practicable, the reconstruction of the highway from the Washington Hill section on Route 179 to Route 20, just west of West Granby.

11. The Corporation agrees, in consideration of the promises and agreements of the District herein contained, to withdraw all its opposition to the passage of said bill, to render to the District reasonable support and assistance for its passage, to send a written communication to the Committee on Cities and Boroughs, to which said bill has been referred, stating the favorable disposition of the Corporation toward the passage of said bill and to make known to the representatives to the General Assembly from the towns of Colebrook, Winchester and New Hartford that it favors the passage of said bill.

12. Said District will have said House Bill No. 610 amended to the effect that the provisions of this contract, in so far as they may be beyond the corporate powers of either party hereto, are ratified and confirmed and made obligatory upon the parties. The provisions of this contract shall become effective only upon the effective date of this act.

APPENDIX G

This is a copy of the Connecticut State Statutes governing the powers of the Metropolitan District regarding water, consisting of Special Act No. 141 of 1963 and Special Act No. 444 of 1949.

Special Act No. 141 of 1963 of the

General Assembly of the State of Connecticut

House Bill No. 3081

SPECIAL ACT NO. 141

AN ACT CONCERNING THE POWERS OF THE METROPOLITAN DISTRICT RESPECTING WATER.

Be it enacted by the Senate and House of Representatives in General Assembly convened:

Section 4 of number 444 of the special acts of 1949 is amended to read as follows: No riparian owner on said Farmington river below said proposed dam authorized by section 1 hereof shall be required, in order to reserve his rights, to assert any claim for loss or damage arising from the construction of said dam and said new reservoir prior to the time when water is actually diverted from said reservoir for use in the water system of said district and the failure to assert such a claim for loss or damage prior to the actual diversion of said water from said west branch of said river shall not consitute laches or waiver or a bar by limitation of time. Before said district shall divert from said reservoir any of the water of said west branch of said river for use in the water system of said district it shall either agree with riparian owners on said Farmington river below the dam of said reservoir upon the compensation to be made to them in lieu of damages by reason of such diversion or it shall by condemnation proceedings acquire the right to divert said water and make just compensation for the water so diverted to any of such riparian owners with whom no agreement for such compensation has been made. The minimum flow through or over the dam of the proposed Hogback reservoir shall not be allowed to fall below fifty cubic feet per second regardless of the actual natural minimum flow.

Special Act No. 444 of 1949 of the

General Assembly of the State of Connecticut

AN ACT INCREASING THE POWERS OF THE METROPOLITAN DISTRICT, RESPECTING WATER.

SECTION 1. The Metropolitan District, for the purpose of improving and increasing the water supply of the towns and the inhabitants thereof to which said district shall furnish water, is authorized to take, hold, conserve, store, utilize, divert and convey to, into and through its system of water works the waters of the so-called main stream or west branch of the Farmington river and its tributaries, which enter said main stream at or north of the Hogback, so-called, for said purposes or for compensation, and for said purposes to build, erect and maintain a dam on said west branch of the Farmington river, at or about the Hogback, so-called, and may take and hold by purchase, condemnation or otherwise any lands, water rights, flowage rights, rights of way or easements or other rights of property, which said district may deem necessary or convenient for constructing said dam, a reservoir, aqueducts, pipe lines, tunnels or other works for the purpose of storing, distributing and utilizing such water supply, for conveying the same between reservoirs or from reservoirs to any part of said district or to any other place which is, or under authority of law may be, supplied with water by said district, and for protecting the purity of said waters and which may be necessary or convenient for the purpose of carrying out the provisions hereof. The provisions of this section shall be subject to the provisions as to minimum stream flow set forth in section 4 hereof.

SEC. 2. Said district may construct and maintain, on land so taken, a dam, a reservoir, dikes, spillways, flumes, canals, aqueducts, wheel-pits, waste-weirs, races, buildings and other works and structures which said district may deem necessary or convenient for taking, storing, purifying, controlling, measuring and distributing the waters hereinbefore authorized to be taken, or for any other purpose hereby permitted, and, for the purpose of conveying the waters of said west branch of the Farmington river and utilizing the same to increase its water supply, may construct, lay, carry, maintain and repair such canals, tunnels, pipes, telephone and electric power wires, or other works, as may be necessary or convenient for such purpose, through or over any lands, rivers or other water courses, railroads, street railways or public or private ways, and over and upon any public bridge now existing or hereafter built; may contract with the public authorities owning or controlling any public bridge or bridges hereafter built for adaptation thereof to the uses herein provided, under such terms as may be agreed upon, for the purposes of this act; may open the ground in any private or public way in any city or town in which any portion of said works is located, under the approval of the selectmen or other proper authority thereof or, if control be exercised by the state over any highway so opened, under the approval of the highway commissioner, in such manner as to cause no unreasonable hindrance to public travel, and shall hold the party responsible for such highway harmless from all liability for, and indemnify it against, all damages suffered and expenses incurred by it from any cause resulting from such acts of said district.

SEC. 3. If said district shall construct said works as authorized by section 1 hereof upon the west branch of the Farmington river, said district may use any part of the water therein stored, which is not needed for its water supply system, for the purpose of returning to said Farmington river at convenient times water in lieu of that, in whole or in part, diverted, and may install such necessary spillways, locks, gates and appliances for regulating the discharge and flow of water in said river for the purpose of maintaining in said river a more constant flow regardless of seasonal variation, and said district may make and enter into contracts and agreements with any person or corporation affected by any such diversion providing that the water so stored, ponded and returned to said river from said reservoir shall be in lieu, in whole or in part, of damages resulting to such person or corporation by reason of such diversion or holding back of said water and may make any and all contracts, agreements and conveyances which may be necessary or convenient to provide for the maintenance, care, operation and control of said reservoir for said purposes; but said district shall retain the right to enforce such limitations on operations as may be necessary for the protection of the primary purpose of the use of said works as a part of its water supply system; and said district is authorized to purchase electric power and to make and enter into contracts and agreements with any person or corporation affected by the diversion of water from said west branch whereby said electricity so purchased by said district shall be delivered or supplied in lieu, in whole or in part, of damages resulting to such person or corporation by reason of such diversion or by reason of the storing or ponding of the waters in said river and for the purpose of furnishing compensation in kind to persons and corporations damaged by the diversion of water under the authority given herein. In substituting electricity, in whole or in part, for water, said district shall supply such electricity through and by agreement with the electric light and power companies authorized to distribute and sell electricity within said territory.

SEC. 4. No riparian owner on said Farmington river below said proposed dam authorized by section 1 hereof shall be required, in order to reserve his rights, to assert any claim for loss or damage arising from the construction of said dam and said new reservoir prior to the time when water is actually diverted from said reservoir for use in the water system of said district and the failure to assert such a claim for loss or damage prior to the actual diversion of said water from said west branch of said river shall not constitute laches or waiver or a bar by limitation of time. Before said district shall divert from said reservoir any of the water of said west branch of said river for use in the water system of said district it shall either agree with riparian owners on said Farmington river below the dam of said reservoir upon the compensation to be made to them in lieu of damages by reason of such diversion or it shall by condemnation proceedings acquire the right to divert said water and make just compensation for the water so diverted to any of such riparian owners with whom no agreement for such compensation has been made. The natural flow of the water of the west branch of the Farmington river shall not be held back at the dam of the proposed Hogback reservoir, except such flow of said west branch as shall be in excess of one hundred fifty cubic feet per second above the dam site exclusive of any water discharged from the Otis reservoir watershed; and the minimum flow shall not be allowed to fall below fifty cubic feet per second through or over the dam regardless of the actual natural minimum flow.

SEC. 5. If any highway or any section of highway is to be overflowed, abandoned or discontinued by reason of the construction or reconstruction of the reservoir under authority given hereby and a substitute highway or section of highway is to be constructed therefor, before any change of location or grade of any highway shall be made said district shall cause a detailed plan to be made indicating the grade and location of the new highway, which may be a town or state aid or trunk line highway, which it proposes as a substitute so as to show fully all changes proposed to be made. If any highway to be flooded or abandoned is a town road and the highway to be substituted therefor is to be a town road, plans as provided herein shall be presented to the selectmen of each town within which highway alterations are to be made. Such selectmen, within fifteen days thereafter, shall issue a call for a meeting of the legal voters of such town to be held within ten days after the issuing of said call and shall submit said plan to such meeting for its consideration. Said meeting may adopt, modify or reject such plan or any part thereof and, within ten days after said meeting and in accordance with the vote thereof, such selectmen shall notify said district of the decision of said meeting thereon or of such modifications therein as have been made. If the plans presented are modified or rejected, said district may at its option thereupon present other plans to such selectmen for presentation to a meeting of the legal voters of such town in accordance with the procedure hereinbefore provided. The proceedings, orders and decisions of any town as aforesaid shall be in writing and shall be recorded in the records of such town. If said district and any town affected by any change of location of any highway hereinbefore described shall not agree upon any plan submitted or if such selectmen of any town shall fail to act thereon as hereinbefore provided, said district may petition the superior court for the county in which such highway or such part thereof is located or, if such court is not in session, any judge thereof, asking said court or such judge to approve one of said plans as presented. Said court or such judge may thereupon cause such notice of such petition to be given as said court or such judge shall prescribe. Unless the parties shall agree as to the judgment to be rendered, said court or such judge shall fully hear said district and all parties interested and shall thereupon approve such plan or make such changes therein as it may decide to be necessary for the purpose of carrying out the provisions hereof, and said district may thereupon proceed with the construction of such highway in accordance with said plan as approved. If any highway to be flooded or abandoned is a trunk line or state aid highway or if the highway to be substituted for any highway to be flooded or abandoned is to be a trunk line or state aid highway, a plan prepared as herein provided shall be submitted to the state highway commissioner and the approval of said commissioner as to location, grade, specification and general details of the highway to be constructed shall be sufficient, or if said district, acting through its district board, and the state, acting through said commissioner, shall enter into an agreement in writing, either with or without conditions, that the state will accept the new highway after construction according to said plans and specifications as a state aid or trunk line highway, then only the approval of said commissioner as to location, grades, specifications and general details shall be necessary. No such highway so proposed to be changed shall be in any way discontinued or obstructed, nor shall public travel thereon be interfered with, until a new highway in lieu thereof has been constructed in accordance with the provisions of this act.

SEC. 6. Said district shall have power to make any contract of purchase for acquiring title to any land, water right, franchise or other property required for or affected by the reservoir or other works herein provided and for acquiring title in the respective towns of rights of way for such highways. Any land on the watershed under the control of the state park and forest commission may be left in such control subject to the rules and regulations of the state department of health regarding public water supplies.

SEC. 7. If said district cannot agree with any owner of land, water rights or other property to be taken for such dam, reservoir and appurtenant works, or for aqueducts, pipe lines or transmission lines, or for the use of water herein provided, or for the construction of highways in lieu of those overflowed, taken, abandoned or altered under the provisions of this act, as to the amount of damages which ought to be awarded to any party claiming to be injured by the doings of said district hereunder, said district may petition the superior court for the county wherein such property so to be taken or damaged is located, or, if said court is not in session, any judge thereof, praying that such compensation may be determined. Said court or such judge may thereupon cause such notice of such petition to be given as said court or such judge shall prescribe and shall appoint a state referee to examine the property which is to be taken or damaged by the acts of said district hereunder, including all damages for any land or water right, title, privilege, easement, franchise or other property which may be required, taken or impaired for the purposes hereof. Such referee, having given at least ten days' notice to the parties interested of the time and place of hearing, shall determine the amount of compensation which said owner or parties affected shall receive and report the same in writing to said court. Any party may remonstrate against the acceptance of said report in accordance with the rules of the superior court. Said court may confirm the doings of such committee and render judgment accepting the report or take such other action as it may determine to be proper. Said district shall pay the amount provided in such judgment, in such manner as said court may prescribe, in full compensation for the property acquired or the injury done by the acts of said district and thereupon said district may proceed with the construction of the dam, reservoir and other works provided for by this act, without any liability upon any further claim for compensation for damages.

SEC. 8. If, to carry out the purpose of this act, any cemetery or land owned for cemetery purposes is to be taken by said district and it shall become necessary to remove such cemetery from its present location and to establish it in another place, the owner or owners of such cemetery, or if there is no known owner or owners, or if such owner or owners shall neglect or refuse to act under the provisions of this act, said district, if land therefor cannot be acquired otherwise, may petition the superior court for the county in which such cemetery is located for authority to take other land which such owner or owners or said district, as the case may be, may consider suitable to be used for cemetery purposes in lieu of that taken under the provisions of this act; and said court may appoint a committee of three disinterested persons who, after examining the premises and hearing the parties, shall report to the court as to the quantity, boundaries and value of the land which such committee shall deem suitable to be taken for said purposes, and the damages resulting from such taking; and if the court shall accept such report, it shall render judgment thereon and execution may be issued thereon accordingly, in favor of the person in whose favor damages are assessed, for the amount thereof; and upon payment thereof the title of the land shall, for such purposes, be vested in such owner or owners of the cemetery taken under the provisions hereof, if known, or, if not known, in the name of the town in which such cemetery is located; but such land shall not be taken until such damages shall be paid to the owner, or deposited with the treasurer of the county for the use of such owner, which payment or deposit shall be made within thirty days after such report shall be accepted. If such application shall be denied, the owner of the land shall recover from the applicant or applicants costs, to be taxed by the court, and the court may issue execution therefor. The owner or owners of such cemetery, or, in the event that such owner or owners shall neglect or refuse to act, said district shall have authority to lay out and establish a new cemetery in place of any taken hereunder, and, in all cases in which the friends or relatives of those buried in any cemetery so taken shall not otherwise provide, to remove the bodies buried in such cemetery, together with the monuments and other property of such cemetery, and place them in suitable manner in the new cemetery herein provided for. Said district shall pay all costs incurred under the provisions of this section and shall reimburse the owner or owners of any such cemetery so taken for all expense or liability incurred in the taking, laying out, or establishing of any new cemetery or in removing the bodies, monuments and other property from such cemetery so taken to any established in place thereof, and shall also bear all expense incurred in the removal of bodies and monuments, by friends or relatives, to cemeteries other than those hereinbefore referred to.

SEC. 9. When lands, rights or other property, or any interest therein, taken or affected under the provisions of this act, shall be owned by an infant, or an insane person, or by a person unknown or absent from this state, or where any person shall be the owner of a contingent or uncertain interest therein, the superior court, or any judge thereof, may make such order for service of process upon such person, or for giving notice to any such person of the pendency of proceedings under this act, or for the appointment of a guardian, conservator, trustee, or other representative for such person, as said court or such judge shall determine, and thereupon all proceedings hereunder shall be binding upon the interest of such person in such lands, rights and property, and said court or such judge may make orders to protect the rights, title and interest of any such person taken or affected by or under the provisions of this act.

SEC. 10. Said district is authorized, after notice to the owner when practicable, to enter upon any land or water for the purpose of making surveys necessary to be made for the purposes of this act, and shall pay all damages caused thereby. Said district shall pay all costs, including costs of committees, incurred in the taking of lands, rights of way and property for any purpose under the provisions of this act, not otherwise provided for herein; and all land taken for any of said purposes shall be set in the list for taxation in the town in which said land is situated, to The Metropolitan District, and assessed for taxation at the average assessed valuation per acre of the improved farming land in such town.

SEC. 11. If after the construction of the reservoir authorized by this act the water in Bushnell or Mill brook, so-called, shall, in the opinion of The Metropolitan District or of the state department of health, become unfit for drinking purposes, said district shall at its own expense divert said brook so that it shall enter the west branch of the Farmington river below said Hogback dam so that the use and improvement of the water-shed around the sources of said brook, including Hartland pond and the Pinehurst lakes and their tributaries in the town of Hartland, for domestic and recreational purposes shall remain undisturbed.

SEC. 12. Said district shall not develop for water supply purposes said west branch of the Farmington river below the Hogback dam site to and including Satan's Kindgom, or Sandy brook, Mad river or Still river or any other tributary of said west branch which enters said river between said points and shall not have any right of eminent domain in respect to land or property rights upon, beneath, along or bordering said west branch between said points, except for the construction, repair and maintenance of pipe lines for water supply purposes. Said district shall not impose any restrictions on swimming or other recreational activities in the towns of Colebrook, Norfolk, Winchester, and New Hartford within the territory of the watershed of said streams. Boating, hunting and fishing shall be allowed upon the reservoir to be constructed under the provisions of this act and within the limits of land owned by the district and located within the watershed of said reservoir and Greenwood's pond. Said activities shall be subject to proper regulations to be determined from time to time by a commission of seven members consisting of one member of the state department of health to be appointed by the Connecticut public health council, one member of the state board of fisheries and game to be appointed by said board, one member of the water bureau of the district to be appointed by the district chairman, and one representative from each of the towns of Colebrook, Barkhamsted, New Hartford and Hartland to be appointed by the board of selectmen of each of said towns, such representative, as far as possible, to be selected from a sportsmen's organization. The members of said commission shall serve without compensation.

SEC. 13. Said district is authorized to acquire by purchase, hold title to, maintain and operate and exercise all privileges of ownership of any land, water right, franchise or other property in Massachusetts required for or affected by the proposed reservoir or other works on either branch of said Farmington river, or necessary or convenient for the protection thereof or of the water supply system connected thereto, and to negotiate and enter into agreements with the Commonwealth of Massachusetts or any of its governmental or administrative sub-divisions, agencies, commissions or boards, or owners or occupants of real estate necessary or convenient for the protection of the water supply system and the operation thereof, including sanitation and elimination of pollution of any natural waterway or any and all of their tributary waterways or watersheds within said commonwealth of Massachusetts, the alteration, relocation or reconstruction of highways and appurtenances, and as to the payment of taxes on any such land, water right, franchise or other property or for compensation in lieu of such taxes. Said district is authorized to comply with any law of said commonwealth or subdivision thereof which may be applicable to it as owner of any such land, water right, franchise or other property. All purchases of land, water rights, franchises and other property heretofore made by said district within said commonwealth are validated.

SEC. 14. The Metropolitan District is authorized so far as is compatible with the primary purposes of creating and maintaining a pure public water supply and compensation to cooperate with the work of the state board of fisheries and game in promoting the increase of the supply of fish and game.

SEC. 15. It shall be the duty of The Metropolitan District and it shall have the right upon passage of this act to proceed forthwith to acquire title by purchase, condemnation or otherwise, to all private land in the town of Colebrook situated within the area bounded on the north by the Massachusetts line, east and south by the town of Hartland, and west by the Farmington river. When said town of Colebrook shall have been notified by said district that said title has been acquired it shall proceed forthwith to discontinue and abandon the town and state aid roads in said area. Said town shall also convey to said district all right and title of the town in and to public lands and all bridges and culverts upon the roads in said area and the bridge on the west side of the river at Brownell's and the triangular piece of land on the west side at the junction of Beech road and the west side highway. The town shall have the right to remove and use the material from any of the culverts on the abandoned roads. Upon performance by said town as hereinbefore described said district shall pay to said town the agreed sum of twenty thousand five hundred dollars.

SEC. 16. Said district may begin to exercise forthwith the rights herein granted to take property by purchase or otherwise.

SEC. 17. The provisions of an agreement dated April 18, 1949, between The Metropolitan District and The Allied Connecticut Towns, Incorporated, so far as they are beyond the corporate powers of either party thereto, are ratified and confirmed and made obligatory upon the said parties. The provisions of said agreement shall become effective only upon the effective date of this act.

Approved, July 26, 1949.